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NEW YORK, FEBRUARY, 1887.

THE death of Sir Joseph Whitworth, which is recorded in another column, calls attention to the fact that his great reputation as a mechanical engineer, and the fortune which he made, were largely due to his early recognition of the value of accuracy in mechanical work. He saw that the methods of testing work then in use were loose and inaccurate, and set himself to work to improve them, with the success of which we all know.

RAILROAD building in the United States this year, from present indications, will include a number of lines already actually begun by companies of sufficient financial standing to secure their completion, and also many minor extensions planned, and very likely to be built. The greater part of this mileage, it may be noted, will be built by old companies to complete or extend their present systems. Of new projects there are an enormous number coming forward, but, as usual, by far the greater part of these will never get beyond the paper stage of existence.

The increased prices of railroad material may check, in some degree, the tendency to extension, but there is little doubt that this year, as well as last, will be a year of activity in railroad construction and in all the trades dependent upon it.

THE narrow gauge, for which so great a future was predicted by its advocates a few years ago, is gradually disappearing in this country. During the past month the St. Louis, Arkansas & Texas Company changed its Texas Division from 3 feet to standard, thus completing its abandonment of the narrow gauge, its lines in Missouri and Arkansas having been changed some months ago. Two lines of considerable mileage remain east of the Mississippi, the Cleveland & Canton, in Ohio, and the Toledo, St. Louis & Kansas City; both of these are to be changed to standard as soon as the money needed can be raised.

By the close of the present year the Denver & Rio Grande will be, in all probability, the only railroad of any importance still adhering to the 3 feet gauge, and this company is not likely to make any change for several years to come, as its location and circumstances are so peculiar that it would not be justified in spending money at present for this purpose.

That a railroad of standard gauge is not only possible but also preferable in a difficult mountain country, is in process of demonstration by the Colorado Midland Company, which is now building a standard-gauge line from Leadville to Aspen, in Colorado. This line will come into direct competition with the narrow gauge of the Denver & Rio Grande, and will parallel one of its most important branches.

THE reports of the New York City railroads to the State Railroad Commission, which are for the year ending September 30, show that last year they carried in all 325,142,075 passengers, which is an average of 890,800 per day. Of this total the four lines of the Manhattan Elevated road carried 115,109,591, or 35½ per cent., while the surface lines carried 210,032,484, or 64½ per cent. This proportion did not vary greatly from the preceding year, and shows that the surface roads still continued to carry the larger share of the passengers. If the passenger mileage could be given the proportion would undoubtedly be changed considerably in favor of the elevated lines, which carry the greater part of the long-distance travel.

It is to be remembered that the year covered by these reports does not include any of the time since the general reduction of elevated fares. For about one-third of the year the fare on the two lines of least traffic was five cents, but the reduction from ten to five cents (outside of the commission hours) was not made until after the close of the year on the two more important lines. That this reduction has largely increased the travel on the elevated roads outside of the commission hours, and especially the short-distance travel, there is no doubt. Much of the additional business has been taken away from the surface roads, but a considerable part must come from that growth of the passenger movement which results partly from the actual increase of population, and partly from the increasing tendency "up-town," which has been very marked for the last two or three years.

The proper management of a passenger movement, which will before long reach an average of one million a day, is a problem which will task the best abilities of engineers and railroad managers.

HEATING RAILROAD CARS.

THE recent accidents which have occurred on the Baltimore & Ohio, and the Boston & Albany Railroads, in which a number of persons were burned to death, have, with renewed and horrible emphasis urged the subject to the attention of railroad managers and the public. The managers of, probably, a great majority of the railroads of the country are anxious to find a car-heater which will remove the danger which must be incurred so long as the fire which warms the cars is carried inside of them, and which will be free from the practical difficulties which have attended the use of the various plans which have been devised for dispensing with stoves. At the January meeting of the New England Club—the proceedings of which are reported on another page—this subject was discussed. There were present a considerable

number of experienced railroad men, and a half dozen or more of inventors of plans for heating cars. As will be seen from the report of the discussion, there were nearly as many different views of the subject as there were speakers. All, with perhaps one exception, were agreed however, that the fire for warming cars should not be inside of them.

It was also brought out by the discussion, that the amount of steam required to heat a train of cars, is only a small fraction of that which can be generated in a locomotive boiler. One of the speakers gave the heating surface in a Baker heater at 5.6 square feet, so that a train of 12 cars would have a total heating surface in its heaters of $5.6 \times 12 = 67.2$ square feet. An engine capable of hauling such a train would have about 12,000 square feet of heating surface in its boiler. But owing to the forced draft and other causes, probably a much greater amount of heat is transmitted through a square foot of heating surface in a locomotive boiler, than is conducted through the same area in a Baker heater, so that locomotive boiler heating surface has a much greater value than that in a car heater, from which it follows that only a small fraction of the capacity of the locomotive boiler—probably less than a half of one per cent.—is required to heat a train of 12 cars. This fact is important, because it is generally believed, and is often asserted, by master mechanics and those who should know, that locomotives cannot make steam enough to draw a heavy train, and heat a train of cars too. If the steam required to warm the cars is so small a proportion of that which a locomotive boiler can generate, then the difference between good firing and bad would compensate for the drain on the boiler for heating purposes. If these are the facts in the case, then the objection so often urged to heating with steam from the locomotive has a very slight foundation.

There are, though, other objections to this method of heating, which were very clearly stated by Mr. Depew, President of the New York Central Railroad, in a recent interview with a reporter of the New York *Tribune* in which Mr. Depew said:

"We make up trains here at Forty-second st., and before the train goes out of the station the engine may be blocks off. It is not always possible to have an engine attached to a waiting car or a train simply to give heat. Another objection to steam is that after a train has left New York for example, it will pick up additional cars at Poughkeepsie, Albany, Utica, Syracuse and so on. These cars have been waiting in these stations in advance of the coming of the train to accommodate passengers and save time. Often they are sleepers in which persons have gone to bed early. They must be kept warm, and how is that warmth to be had from an engine drawing a train miles away? It has been proposed to have a special boiler attached to the baggage car, with a special attendant. This would give heat to the complete train, but I don't know that the plan has ever been put into any kind of successful operation. What must be devised is a source of heat for each car, without the use of fire."

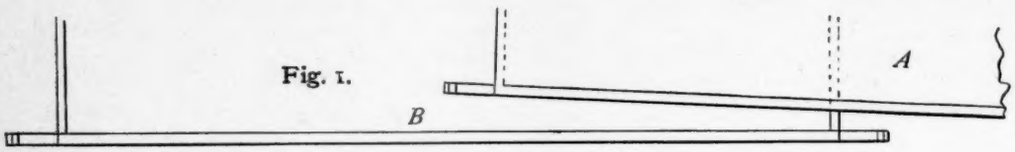


Fig. 1.

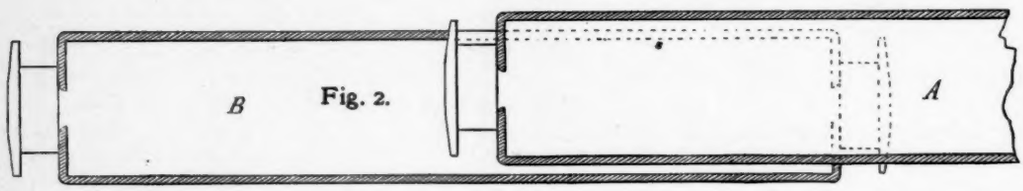


Fig. 2.

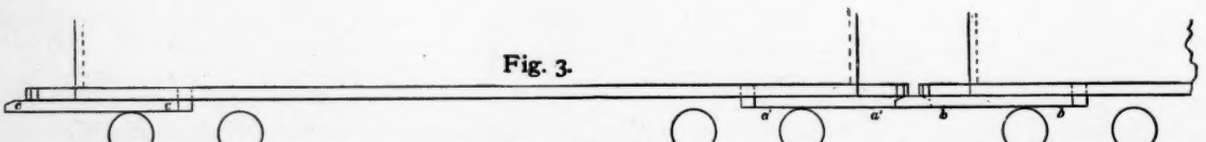


Fig. 3.

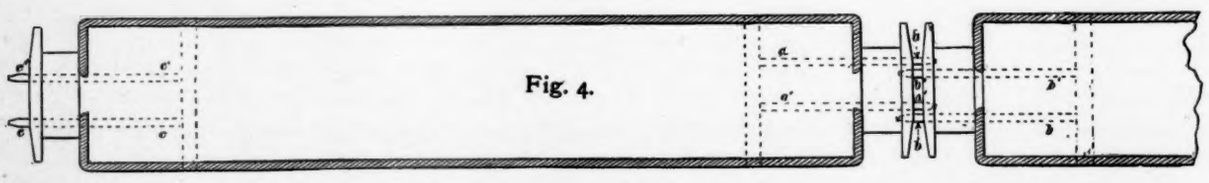


Fig. 4.

There is, besides the difficulties stated by Mr. Depew that of the flexible connections for the steam pipes between the cars. These are liable to burst, leak or freeze up, and when rubber hose is used, it must be replaced often. These objections may not be prohibitory of the use of the system, but they are serious.

Sometimes when a problem of this kind is presented, the solution may be found very close at hand. It may be, that in this case, the method which is so commonly used for heating houses with warmed air, could be satisfactorily adapted to heating cars. In houses, a stove is placed below the floor, fresh air is admitted to a casing surrounding the stove, and this is distributed by suitable flues and

openings to the apartments above. When this system has been applied to cars, it has usually been arranged so that the attendants were obliged to go outside of the train, to regulate and replenish the fire. To this there are loud complaints and objections from the attendants, and their opposition seems to be the most serious difficulty there is in the way of its use. If, then, it were possible to attach a stove below the floor, and feed and regulate the fire from the inside, then the comfort of the brakeman and the porter, would not be seriously disturbed in the performance of their duties, and the objection to the system which has been mentioned would be removed.

If we look about for a stove suited for this service, we find that one of the ordinary base-burning type is admirably adapted for the purpose. It can be attached to the floor of the car, and communication be made, so that it can be fed from above, or from the inside of the car. Mechanism can readily be devised for shaking the grate and regulating the dampers. The whole could then be enclosed in a strong sheet-iron casing, covered with some non-conducting material, to prevent the heat from being conducted away. By suitable flues fresh cold air can be admitted between the casing and the stove, and when it is warmed it can be conducted to, and distributed in the car by other flues, as is often done now in both cars and houses. There is nothing which is novel or untried in the appliances which are proposed. The system is in general use in houses, and to a limited extent in cars. It is true it has in some cases failed in cars, for want of proper attention, or knowledge of the construction of some of the details. Stoves which are so complicated in their construction that they are never used in houses, are sometimes put under cars with the vain hope that the intelligence of the brakeman or the porter will master their mysteries. Now, the first requisite of a car stove is, that it should be simple, and the more it resembles an ordinary house stove the better, because then the knowledge which the attendants acquire at home, in managing their own stoves enables them to take proper care of those which warm the cars. A complicated stove is potentially condemned before it is applied to a car.

Next, if the car is heated by warmed air it is essential that, within somewhat wide limits, the supply of cold air admitted to the stove, and, after it is warmed, to the car, should not be either too great or too small. If it is admitted by a fixed hood on top of the car either too much air will enter when the wind is ahead, or too little when it blows from the side. It is, therefore, desirable that a revolving hood should be used, with a vane attached so as to be directed towards the wind. If this is done a comparatively small opening—with about 30 or 40 square inches of area—will be found sufficient.

Care must also be taken to distribute the warmed air in the car properly. Instead of using registers in the flues, it seems to be a much better plan to make the flue which supplies the warmed air with a larger number of small perforations. The number of these should increase the farther the flue is from the source of the supply of air, because at the far end of the flue the pressure of the air is reduced, and a smaller quantity will therefore flow through the openings.

It is objected to this method of heating, that the stoves are still a source of danger, as they are attached to the cars. To this it may be answered, that in case of an accident, if the stove is knocked off the car, it ceases to be a source of danger, and, by covering the bottom of the car with sheet-iron, it can be protected from the fire in the stove so long as the latter is not broken loose. It is true that in accidents like that at Ashtabula, when the cars are run, or fall, on top of each other, the stoves might then set fire to the cars, but in nearly all cases it would lessen the risk of burning if the stoves were inside the cars, where the fire could he reached and extinguished, instead of outside of them, where it is inaccessible. As an experienced car-builder remarked at the Boston meeting, he "would much rather take his chances in an accident with the stoves below the car than he would if they were inside." The opening inside of the car for feeding the fire could readily be made secure with a suitable cover.

The danger from burning up in accidents nearly always arises from passengers being fastened in the wreck and unable to escape. In the recent and in many other accidents this was due to the telescoping of the cars. Whatever lessens the danger of that, therefore diminishes the risk of persons being burned.

It was supposed that when the Miller platform was introduced that it would entirely prevent the telescoping of cars; but recent accidents have shown that such is not the case. No doubt the Miller platform will resist shocks which would have crushed the old-fashioned cars which were used before it was introduced; but what generally occurs in collisions now is that the floor of the one car mounts above that of the other, as shown in Fig. 1. The position of the two car bodies is shown in a plan view in Fig. 2. It will be seen that when the cars get into this position, that the only thing which resists the car A from crushing or telescoping with B, is the side *s s*. This consists of posts and panels and has very litttle strength. If, however, the floors of the cars could be kept in line, or the one be prevented from raising above the other, then the shock would be resisted by the longitudinal sills in the floor which have a great deal of strength. What is needed, therefore, is some device to keep the floors of the cars in line, and prevent the one from raising above the other. Happily, we have not far to go to find such a device. The Blackstone platform and coupler have been in use on the Chicago & Alton Railroad for some fifteen years or more. Of the coupler no other mention need be made. The peculiar feature of the platform referred to is shown by Fig. 3, which is a side view, and Fig. 4, a plan of the floor framing. At each end of the cars, two safety beams, A A′ and B B′, which project beyond the buffer-beams, are fastened below the floor-sills. The safety-beams are not placed at equal distances from the center of the car, but one is further from it than the other, so that when one car adjoins the other, as shown on the right side of Fig. 4, the safety-beams interlock, as shown. It will also be seen that those in the one car project under the buffer-beam of the other, so that the one cannot raise up without taking the other with it. In this way the floors are kept in line and the longitudinal beams must resist the shock of collision instead of one side only, which has little more capacity of doing so than the paper in hoops has of opposing the leaps of a circus-rider.

These safety-beams are the invention of Mr. Blackstone, President of the Chicago & Alton Railroad Company. As safety-guards, in case of accident, they appear to have as much value as the Miller platform, although there is no reason why they should not be used conjointly. Prob-

ably if Mr. Blackstone had urged the adoption of his invention with the same vigor, and with the same methods, that were employed to make the Miller platform known, the former would now be as generally used as the latter is. There is little doubt that if the Blackstone device had been adopted, that we would have been spared the horrors of some of the accidents that have occurred in recent years.

NEW PUBLICATIONS.

"A SKETCH OF THE LIFE AND WORKS OF GEORGE W. WHISTLER, C. E."—*By George L. Vose, President of the Boston Society of Civil Engineers.* Boston: Lee & Shepard.

This little book is a brief history of one of the early and most noted of American engineers. It is printed in a very luxurious manner and is prefaced with a portrait apparently some kind of photo-copy of a lithograph. The author has collected together the important events and work of the subject of his memoir, which to the rising generation of engineers, are probably entirely unknown. In fact, the time appears to be not far off, when a career like that of Major Whistler's will have more or less of romantic interest, from the fact that such professional experience will be quite obsolete. Engineering is every day becoming more and more specialized. The man who locates a railroad no longer designs the bridges, and firms and companies confine themselves exclusively to building either wood, iron or stone structures. This process of differentiation goes on continually, and there are makers who devote themselves exclusively to the manufacture of one kind of car-wheels or one particular form of springs for car-seats.

In the early days of railroads, there were no engineers, even of the kind into which Major Whistler and his professional cotemporaries developed. There were only military engineers, and consequently when some of these were detailed for work which was not military, the term "civil engineer" had to be invented to distinguish those who were no longer military. In 1828, the Baltimore & Ohio Railroad made a special request upon the Army Department for the services of Lieut. Whistler, and he with several others were sent to England to examine the railroads in that country. He was afterwards engaged on various railroads and canals, and in 1842 he received an offer from the Emperor of Russia to act as consulting engineer of the road to be built from St. Petersburg to Moscow. He remained in that service until his death in 1849.

Of his professional ability, Prof. Vose writes that "he was eminently a practical man, remarkable for steadiness of judgment, and for sound business sense. Whatever he did was so well done, that he was naturally followed as a model by these who were seeking a high standard. Others may have excelled in extraordinary boldness, or in some remarkable specialty; but in all that rounds out the perfect engineer, whether natural characteristics, professional training, or the well-digested results of long and valuable experience, we look in vain for his superior; and those who knew him best will hesitate to acknowledge his equal."

BOOKS RECEIVED.

"THE PORTABLE ENGINE, ITS CONSTRUCTION AND MANAGEMENT."—*By William Dyson, Wansborough.* London: Crosby, Lockwood & Co.

"BULLETIN OF THE UNITED STATES GEOLOGICAL SURVEY." *Numbers 30, 31, 32 and 33.* Washington: Government Printing Office.

CATALOGUE OF THE BROWN & SHARPE MANUFACTURING CO."—January 1, 1887. Providence, R. I.: Brown & Sharpe Mfg. Co.

OBITUARY.

SIR JOSEPH WHITWORTH, the eminent English mechanical engineer, died at Monte Carlo, January 22, aged 83 years. He was born in Stockport, England, and at the age of 14 was placed in a shop belonging to his uncle. After mastering his trade he worked in various shops in Manchester and London, and in 1833 started for himself as a toolmaker in a small shop in Manchester. His business gradually increased as he gained a reputation for careful and accurate work. About 1840 he attracted attention by making, after many attempts, surface plates which were perfectly true, or so nearly so that no imperfection could be detected. This work increased his reputation, and his business increased steadily. In the London Exposition of 1851 he again attracted attention by a machine capable of measuring the millionth part of an inch, and by his standard screw threads, gauges, etc.

The improvement of cannon was then a subject of much interest, in which Sir Joseph Whitworth took part. In 1855 he patented the famous Whitworth gun, with its polygonal projectile and its construction differing from that of all rifled guns which had proceeded it, and for years much of his attention was given to this work.

Meantime his works has grown to be a very large establishment, and he turned it over to a joint stock company, in which a number of his workmen were stockholders, retaining a controlling interest for himself.

In 1868 he founded what are known as the "Whitworth scholarships in mechanical science;" they are 30 in number, of an annual value of $500 each. In 1869 he received the title of baronet.

For some 15 years past Sir Joseph spent much of his time in experimenting largely in ordnance, armor plate for vessels, etc. His experiments in casting steel under pressure are well known. Lately his health began to fail, and he was at Monte Carlo in the hope of benefiting it.

PROFESSOR EDWARD L. YOUMANS died at his residence in New York, January 18, aged 65 years. He was born at Coeymans, N. Y., and spent his early life in Saratoga; in 1851 he went to New York City, where he had lived ever since. About the same time he began to compile and write scientific books, having overcome by his own energy and ingenuity the obstacles to study presented by an illness which impaired his sight, and even rendered him totally blind for a time. By the aid of a machine which he devised, and the partial recovery of sight, he wrote the *Class-Book of Chemistry* for common schools, which was published in 1852. After this he lectured extensively and successfully before lyceums, and was perhaps the first to popularize the new doctrines of the conservation and correlation of forces, upon which he subsequently compiled a book. Mr. Youmans's interest in scientific culture, and in the diffusion of the advanced philosophical ideas of the age has had noteworthy results. He early exerted himself for the reproduction in the United States of the works of Spencer, Darwin, Mill, Bain, Huxley, Lecky, Tyndall,

Mandsley, Carpenter and other eminent thinkers. He succeeded in effecting an arrangement with the American publishers with whom he associated to pay foreign authors as American authors are paid. In 1871–72, Mr. Youmans became much interested in the question of international copyright, and went abroad to organize the *International Science Series*, on the basis of a simultaneous publication in different countries of scientific books, for which equitable payment should be made to the authors. He established the *Popular Science Monthly*, and conducted it successfully for a number of years.

GENERAL CHARLES P. STONE died of pneumonia at his house in New York, January 24, aged 62 years. He was born at Greenfield, Mass., and graduated from West Point in 1845. He was appointed to the Ordnance Department, and served until 1856, when he resigned from the army, and was for several years employed as Chief of a Commission for the survey and exploration of the Mexican State of Sonora. In 1861 he re-entered the army and served until 1864, reaching the rank of Brigadier General of Volunteers. In 1862 he was arrested and confined in Fort Lafayette under charge of corresponding with the enemy, but was subsequently acquitted by a court martial, and returned to the service.

In 1870 he accepted an offer to enter the service of the Khedive of Egypt, and was appointed Chief of the General Staff of the Egyptian Army. This position he held until 1883, and through him a number of American officers received appointments in Egypt.

In 1883 General Stone returned to the United States, and was appointed Chief Engineer of the American Committee for the erection of the Bartholdi Statue of Liberty. His last illness was very short, and his denth was unexpected.

GENERAL WILLIAM B. HAZEN, Chief Signal Officer of the United States Army, died in Washington, January 16, aged 56 years. He was born in West Hartford, Vt., and graduated from West Point in 1851. He served during the war as Colonel, Brigadier General and Major General of Volunteers. After the war he was made Colonel of the Thirty-eighth Infantry, and in 1880 was appointed Chief Signal Officer of the Army, having in that capacity control of the Weather Bureau, and became widely known throughout the country. General Hazen was a faithful and efficient officer, but his administration was much criticised, and a pugnacious disposition involved him in many controversies, and made him many enemies.

JOHN ROACH, the noted ship-builder, died at his residence in New York, on Jan. 10th. He was born in Ireland in 1813. His father failed when he was 14 years old. Soon after he came to this country, and commenced life as many other successful men have, with nothing but their own character.

The following account of his life is taken from the New York *Sun:*

Soon after coming to this country he got work at the Howell Foundry, then owned by James Allaire, and began his career in the iron business.

Three years later he found himself with a capital of $1,200. He went West with $500, leaving $700 with Mr. Allaire. Allaire failed. Mr. Roach had paid $500 on some land, the site of the present city of Peoria, Ill., and the loss of the $700 stranded him. By working on a canal he saved money enough to get back to the foundry. Three weeks later he started with some of his fellow workmen an independent foundry. It prospered, and they soon had $1,000 to their credit. His partners thought things were going at too alarming a pace, and that they should draw out while they had the wind in their favor. Mr. Roach bought them out very readily. That was some forty years ago, and in 1885 the same men were working for Mr. Roach in the Morgan Iron Works in the same capacity they occupied when they entered into the foundry enterprise.

Mr. Roach conducted the foundry independently for about six years, and then another of those disasters which seem to have dogged his footsteps persistently all through his life, came upon him and ruined him again. A heavy boiler in the works blew up, shattering everything, levelling the building to the ground and killing six men. He found a man who would lend him a little money, not all he wanted, to be sure, yet enough to warrant him in making another venture. He rebuilt his buildings and was soon at work again. From that day on his business steadily increased beyond the most sanguine hopes. It outgrew plant after plant. He bought the big Morgan Iron Works, at the foot of East Ninth street, in this city, and in 1871 he bought of Rainer & Sons, the big ship-yard at Chester, where, at one time, he gave employment to more than 3,000 men. For the Morgan Iron Works he paid $400,000.

It had been his dream to revive American ship-building, and to prove to the world that it was folly to fancy that nowhere could so good ships be built as on the Clyde. His ambition in the foundry line was pretty well satisfied. Besides the Morgan, Ætna, the Neptune and the Franklin Forge, he bought out the old Allaire Works, where he got his first job. He devoted himself almost exclusively to the Chester ship-yards. Vessel after vessel was turned out in rapid succession. Besides those from the Government he had contracts from the Pacific Mail Company, the Mallory line, the Oregon Navigation Company, the Old Dominion, and half a dozen other of the largest American lines, turning out for each first-class vessels, ranging in size from 5,000 tons down. Among them were the enormous Pacific Mail steamships *City of Tokio* and *City of Pekin*, plying between San Francisco and Japan and China. In twelve years the Chester yards turned out, completed, sixty-three vessels.

Mr. Roach was always a strong protectionist, and a believer in subsidies. He argued both in pamphlets and magazines, and orally, with a good deal of energy, that it would be impossible for an American company, even though the ships were given to it free of cost, to compete with an English line unless the Americans received a handsome subsidy.

Mr. Roach's relations with the Government, and particularly his unfortunate last contract, which resulted in the refusal, at first, of the *Dolphin*, and was followed by Mr. Roach's failure, are all fresh in the public mind. The closing of Mr. Roach's great workshops was, undoubtedly, the severest blow of his life.

Proceedings of Societies.

American Society of Civil Engineers.

A BUSINESS meeting of this Society was held in New York, Jan. 5. After business relating to the annual meeting had been disposed of, a number of written discussions of Mr. Dorsey's paper on Irrigation were read.

These discussions developed mainly the following points:

1. "Duty" (so called) of irrigation water. This is the number of acres which one cubic foot of water per second flowing through the irrigation canal will irrigate. This ranges from 56 acres on the very lavish system in vogue in Colorado, to 1,500 acres on the hose-watering system used in California for orchards. Under the latter plan, only a small space immediately around each tree is

watered. For a true irrigation system conducted economically, the duty may be set down as 150 to 200 acres, according to the amount of rainfall of the region, and assuming that the region will not produce a crop which will pay for cultivation without irrigation. Of course, where there is enough rainfall to get along with, except in very dry times, the duty will be increased over the above figures.

2. The injurious effects of irrigation on certain crops. From the California experience it is not at all clear that irrigation is advantageous for cereals in proportion to the expense of irrigating. For clover and roots of all sorts it is generally admitted to be highly profitable. For fruits of all kinds there is strong opposition to it in California. It is reported to increase the size of fruits, but to render them insipid and less able to bear transport.

3. The abrogation of riparian rights. The laws of the States and Territories where irrigation is absolutely necessary to secure crops, such as Colorado, Utah and Wyoming, have repudiated the right of the riparian proprietor to the water of streams, unless actually used by him for irrigation, viz.: An irrigation company may appropriate the entire flow of a stream not yet made use of for irrigation, but if they do not carry the whole flow, other parties may appropriate any portion of the flow which is not needed to fill the canal of the parties already in possession.

THE ANNUAL MEETING.

THE annual meeting of this Society was held in New York, January 19 and 20.

On Wednesday, January 19, the meeting was called to order at 11 o'clock, and Mr. C. E. Emery was called to the chair.

The report of the directors stated that 114 members had been added during the year, and 16 had been lost by death, transfer, etc. The number of members now is 1,019, an increase of 98. There had been an unusual activity in the Society during the year, and there were more papers contributed to the *Transactions* than in any previous year.

The Norman medal for the year was awarded to Mr. Edward Bates Dorsey, member of the Society, for his paper on English and American Railways compared.

The Rowland prize was awarded to Mr. Charles C. Schneider, member of the Society, for his paper entitled the Cantilever Bridge at Niagara Falls.

The Committee on Uniform Standard Time made an interesting report on the progress of the movement for its adoption, with particular reference to the Canadian Pacific Railway. This company has given it about a year's trial on the western division and branches, comprising altogether 2,600 miles of road. Letters were read from conductors, train dispatchers, superintendents, and the Assistant General Manager. They all spoke of its simplicity, absolute freedom from ambiguity in orders, and consequent increase of safety to passengers and traffic, of its ready adoption by the public, its great advantages in the movement of trains, etc., and they all desire its adoption over the whole line and connecting roads. It is understood that the Canadian Pacific will, within the year to come, adopt the new method over its whole line.

The Society passed resolutions recommending Mayors of cities to have clock-dials on public buildings arranged for its use, and the post-office authorities also recognize it in an official manner. The Committee was continued.

The Committee on the Form of Rails and Car Wheels presented a short report and was continued.

The Committee on Compression of Cement, Mortar, etc., under strain, made a report of progress, and referred to important information, soon to be published, which has been obtained from tests made at the Watertown Arsenal.

The place of the next convention was discussed, and the feeling strongly expressed that it was not desirable to meet in a large city. Newport, Saratoga, the Thousand Islands, Old Point Comfort, etc., were all suggested, and a resolution passed referring the matter to the Board of Direction, with the proviso that the place selected shall have a hotel large enough to accommodate all who may attend, and that it shall not be near a large city.

The result of ballot for officers was then announced as follows: President, William E. Worthen; Vice-Presidents, Thomas C. Keefer, Thomas F. Rowland; Secretary, John Bogart; Treasurer, J. J. R. Croes; Directors, William G. Hamilton, Charles C. Schneider, Stephenson Towle, James Archibald, Robert Forsyth.

After lunch in the Society's rooms, an afternoon session was held. The chief business was a discussion on the Prevention of Pipe Corrosion, in which the chief points developed were the excellent effect in this respect of riveting on pieces of zinc to the outside of wrought-iron pipes, and the fact that cast-iron pipes laid in dry sand in Philadelphia had remained for 52 years entirely free from corrosion, while the same pipe line where it passed through gravel fell to pieces shortly after being removed.

An evening session was held at 20:30 o'clock, when Mr. Charles Macdonald read the paper on a Large Testing Machine which is published elsewhere in this issue.

The reading of this paper was followed by a long and interesting discussion, in which a number of members took part. Lack of space prevents us from giving a summary of this discussion.

On Thursday, January 20, the members visited and inspected the new Suburban Rapid Transit road, and the new bridge over the Harlem River at Second avenue. They then visited the Continental Iron Works and Greenpoint, and wound up by a visit to the Statue of Liberty.

The reception at the Society's house in the evening was largely attended and much enjoyed. Supper was served at 21.30 o'clock.

New England Railroad Club.*

THE January meeting of this club was held on the evening of the 12th, with President Marden in the chair. The subject for discussion was "Heating and Lighting Cars in Passenger Service."

A number of letters were read from manufacturers and inventors of appliances for heating cars, describing the appliances which they have devised.

Mr. J. A. Coleman, of Providence, said that he believed it is just as proper to heat a train of cars from some central point, away from the cars, as it is in a house. He can see no reason why a boiler could not be placed in the baggage car and heat the passenger coaches from that. He thought some means might be devised by which main pipes might be run under the cars and so arranged as to supply heat evenly in all parts of the car. He suggested as an answer to the objection that cars cannot be heated when the locomotive is unattached, that a boiler might be located in the station so as to heat the cars by flexible connections.

President Marden said he had no doubt every railroad would like to get rid of the stoves in each car, but there are some questions he would like to have answered, and he proceeded to speak of the difficulties to be overcome where trains run out of the stations with only three or four minutes between them, and where cars are taken on or left off at branches.

Mr. J. N. Lauder, of the Old Colony Railroad, suggested that the system of heating was the one to be considered. The heating with hot water, he thought, had proved very successful, and the only possible objection he saw was the possible danger of one of the heaters breaking away from its fastenings and setting fire to the car in case of derailment. He had never heard, however, of one of these heaters ever setting fire to the cars, though he had known of their being torn from their fastenings. Still, there may be danger some time. He had thought of inclosing the heater in a compartment of boiler iron, but that derailment might take place when the doors were opened to replenish the fire. Placing the heater in the baggage car would not do away with the danger from fire, because the baggage car, in case of derailment, might be buried up beneath the passenger cars. Mr. Lauder said he believed the Old Colony has the best system of heating in the

* The most of the following report is from the *Boston Herald*.

world. He contended that, with the various stations where cars stand all night on his road, the system of heating from the locomotive is impracticable.

Mr. W. Martin, the inventor of the Martin anti-fire car-heater, said he has often heard the same objections as advanced by Mr. Lauder against heating with steam from the engine. He said the objection that steam taken from the engine would cripple it, has been proved, on the Boston & Albany Railroad, to be entirely baseless. He contended that the economy and safety to be obtained in heating from the engine are sufficient to lead every railroad to change its methods of operating its passenger service. He claimed that by his system the cars can be warmly heated in the coldest weather. When the train on the Boston & Albany road is ready to go out, the engine is attached about ten minutes before starting, and quickly heats it.

Mr. Emerson said that his system of heating cars has been in use on the Connecticut River Railroad for the past five years. He first tried a boiler in the baggage car, which was a nuisance. His method is to heat with steam taken from the engine. He then has a small boiler under each car, which is filled from the drip from the engine. This boiler can be fired up in case the engine is detached from the train. He found 1¼-inch pipe was the best size to use. At Holyoke, the railroad company had pipes arranged so that the cars could be connected with the boilers for heating the engine-house. By this means the cars could be warmed in from ten to twenty minutes, while standing at the station. The pipes in the cars are connected together by rubber hose, which cost 75 cents each and would last a few months.

Mr. G. W. Cremer said he thought it was time to have something said on the other side. They had heard of nothing but steam. He said he thought if they would place a coil of pipes in one end of the car, surround it with sheet-iron, let the cold air into the center of this coil, and then conduct this heated air along the sides of the car, they would get both the heat and the ventilation.

Mr. Chase said he had been able to heat, by exhaust-steam, a building 1,500 feet from the engine, and he, therefore, saw no reason why the longest train cannot be heated from the engine, nor why trains cannot be heated from boilers in stations before the engine is attached.

Mr. A. G. Gouge, of New York, said that some years ago, at a meeting of master car-builders, it was decided that it is necessary to admit fresh air into the car, and if so, it is necessary to heat it, and thus you get heat and ventilation both. He asked if it would not be well for the club to get up a bureau of experts who would pass upon all the several inventions.

Mr. Johnson said that he had sold about 600 of his heaters, and that it could not set fire to a car.

Mr. M. N. Forney was invited to give his views. He said he believed people are rapidly coming to the idea that the fire for heating the cars must be put outside, and if the railroads don't do it, the Legislatures will compel them to do so. The Reading Railroad has been heating a large number of its cars with heaters under the cars, and it has been doing so for ten years. He did not say there are not some objections to the system in use on the Reading, but he thought if a law should be enacted making it compulsory to put all stoves under the cars, inventors would quickly devise improvements in the various systems now in use. Mr. Forney referred to the telescoping of cars in case of collision, and explained, by drawings on the blackboard, inventions designed to prevent such accidents.

Mr. Creamer inquired if, in the recent accidents, the fires had not been caused from inferior heaters in baggage cars, and if all railroads do not put inferior heaters in their baggage cars.

Mr. Rose, President of the Main Water-Gas Company, explained the manner in which that company is heating and lighting cars.

Mr. Creamer stated that last fall the Reading Railroad bought sixty stoves to put inside their cars, and also said that two cars, heated by stoves under them, had been burned recently.

Mr. Adams said he thought the danger from a stove under the car would be as great as if it was in the car. He said his judgment is that steam is the "coming heat" for cars. He indorsed the Martin system, now being tried on the Boston & Albany.

Mr. Marden remarked that, in case of accident, he would much rather take his chances with a stove under the car body than with one inside.

Mr. Folsom thought that the stoves had been abused more than they deserve, and he did not think that it had yet been clearly established that in any of the accidents the stoves had set fire to the cars. He thought that, ordinarily, the ventilation of cars was reasonably good, that the doors are opened frequently, and there are numerous crevices that admit the air, and, speaking humorously, he said there are the two key-holes which admit some air.

Mr. Creamer and Mr. Coleman both protested, and said that the ventilation was often outrageously insufficient, to which another gentleman uttered a profound amen.

After some more desultory discussion the meeting adjourned.

At the next meeting of the Club, which will be held at the rooms in the Boston & Albany station, in Boston, on the evening of February 9, the subject of Heating and Lighting Cars will be continued.

The Master Car-Builders' Club.

THE regular monthly meeting was held at the rooms, No. 113 Liberty street, New York, on the evening of Thursday, January 20. Mr. C. E. Garey presided.

The committee appointed at the last meeting (Messrs. C. A. Smith, Willis Davis, J. T. Leighton, W. R. Davenport and C. R. Woodin) presented a brief memorial on the late Leander Garey, with resolutions, which were unanimously adopted.

The Chairman stated that the subjects for discussion were: Car Coupling, with reference to the two leading classes of couplers, the Hook and the Link and Pin types; and the value of Slack in starting trains. It was not the intention to discuss the merits of individual couplers, but those of the two leading types or classes.

Letters were read from Messrs. J. R. Kinsey, W. J. Lorraine and Peter Campbell, all referring to the advantages of a certain amount of slack in starting freight trains.

The Chairman urged the importance of the adoption of some form of automatic coupler, in view especially of the disposition to take legislative action.

Mr. Baker (Delaware, Lackawanna & Western) said that they had tried some 12 different couplers. They had found the best results with a certain amount of slack.

Mr. Thurmond said that slack could be given in a vertical plane or hook coupler, as well as with a link and pin.

The discussion was continued by Messrs. Colburn, Cook, Shinn, Opdyke and Smillie.

Mr. Hien believed that the best results, so far as starting trains is concerned, is obtained by increasing the play of the bunter springs, not by giving slack in the coupling. He also referred to the increase which had been made in weight of cars and trains without corresponding increase in strength of draw-bars, and said that the links now used in coupling were far too weak.

Mr. McKeen said that he had been promised by Superintendent Goodwin of the Lehigh Valley road opportunities for an open test of couplers on that road. Due announcement will be made as soon as the details are arranged.

A recess was then taken to enable representatives of couplers present to explain the merits of their respective devices.

After the recess the discussion was continued by Messrs. McNally, Hien, Neale and others.

The Chairman announced that the regular subject at the February meeting would be the Heating and Lighting of Passenger Cars. The question of changing the name of the Club and finding other quarters would also be brought up. The meeting then adjourned.

Contributions.

PERFORMANCE OF A PUMPING ENGINE.

BY JOHN W. HILL, M. E.

(Concluded from page 21.)

During the preliminary test of the engine, Dec. 19–21, 1885, an attempt was made to check the calculated delivery of the pumps, by an estimate of the rate of inflow to the well corresponding to the level to which the surface of the water was lowered with a given speed of the engine.

For this purpose the well was pumped down to a level, 15.18 feet below the B. M. from which the stages of water were taken during the trial for duty, the engine stopped and the well allowed to fill by infiltration to a level 6.48 feet below B. M., when it was again pumped down to 15.06 feet below B. M. and again allowed to fill by natural process to 7.25 feet below B. M.

During these tests the levels in the well were taken every 30 seconds, one observer holding the line and float and reading the levels on the line from B. M. as an index; another noting the time; and two others independently entering the time and levels in separate note-books as they were called off.

It was intended, in this experiment, to pump the well down below the lowest point which would probably be reached while pumping with the engine at contract speed and this point was fixed upon the judgment of the engineer in charge of the house; but, unfortunately, upon working the engine afterwards for several hours at contract speed, the level was drawn down below the lowest in the tests for rate of inflow, and recourse was had to calculation to determine the rate of inflow at the lower levels.

The set of observations first taken of the rate of inflow to the pump well contained three known errors of time readings, which were rejected, and a curve constructed from the remaining observations was handed Prof. H. T. Eddy, of the Cincinnati University, with a request to locate the asymptotes and extend the branches of the curve, whereby rates of inflow at levels above and below those taken might be read off graphically.

In locating the asymptotes and extending the curve, Prof. Eddy had no knowledge of the probable rate of inflow to the well. but was informed that the maximum level might be found approximately 0.5 foot above the highest level read, and was limited, in developing an equation for the curve, to the 107 observations of time and line readings taken during the experiment.

The lowest point from which observations of rate of inflow were taken was 15.18 feet below B. M., while the average and nearly uniform level for 17 hours' operation of the engine, at 134.32 feet piston speed, was 16.8 feet below B. M.

From the projected curve of observation. the time required to raise the level from 17 feet below B. M. to 16.6 feet below same datum,was 0.42 minute, exhibiting a mean rate of rise of level of $\frac{0.4}{0.42} = 0.952$ foot per minute.

The well was carefully measured, and found to have a diameter of 20 feet at the coping, which was flush on the inside with the surface of the curb; and assuming (as it appeared to be) a uniform diameter for all depths, then a rate of inflow or rise of 0.952 foot per minute represented 299.08 cubic feet, or 2237.12 gallons per minute, as the delivery from surrounding soil to the well. 2237.12 gallons per minute is equivalent to an inflow of

$$2237.12 \times 1440 = 3,221,452.8$$

gallons per diem.

During the 17 hours of preliminary test, the engines worked at an average speed of 26.8647 revolutions per minute, corresponding to a displacement of plungers of

$$81.706 \times 26.8647 \times 1440 = 3,160,810$$

gallons per diem.

The mean consumption of injection water (which was drawn from the suction pipe) is estimated at 30 pounds per pound of steam condensed, and the weight of steam delivered to the condenser as 17.33 pounds per indicated horse-power per hour, as estimated from the data of subsequent duty trial.

The indicated horse-power of the engine for the 17 hours of trial, Dec. 20–21, from careful measurements of the indicator diagrams, was 80.25; and probable injection water per diem

$$\frac{80.25 \times 17.33 \times 30 \times 24}{8.33} = 120,207 \text{ gallons.}$$

(Temperature of injection water, 52° F.)

The mean surface of water in pump well during the 17 hours of trial, Dec. 20–21, 1885, was 16.8 feet below B. M., and the calculated inflow 3,221,452.8 gallons per diem.

Of this quantity, it is estimated that 3,221,452.8—120,-207 = 3,101,245.8 gallons were discharged through the pumps, or at this rate for the period of trial, leaving 59,564.2 gallons, or 1.89 per cent. of plunger displacement, to cover loss of action of the pumps.

Subsequent to the trial for duty, the engine was operated for test under the provision of the specification and agreement, which requires a fire pressure of 130 pounds, at 130 feet piston speed, with 70 pounds steam pressure.

To accomplish this, the high-pressure cylinder was worked at full stroke, and steam direct from the pipe was taken through an 1¼ inch bye-pass pipe into the low-pressure cylinder.

A few minutes after this test was commenced, a joint over the dome of the boiler in the old boiler-house blew out, preventing an operation of the engine for the full time desired. The pressure for fire purposes was understood to mean the total head against which the pumps work, and was measured from the surface of water in the pump well as in the duty trial.

During this test, the steam and water-pressure gauges were read independently every two minutes by two observers, and the engine counter and level of water in the pump well similarly noted, with the following results:

Average steam pressure	68.75 pounds.
" revolutions per minute	24.266
" piston speed per minute	121.111 feet.
" water-pressure gauge, "A"	115.23 pounds.
" " " " "B"	112.90 "
" " " " both	114.065 "
" level of water in pump well, below B. M.	15.427 feet.
Bench mark, below water-pressure gauge	18.00 "
Difference surface of water in pump well, and cent. water-pressure gauge	33.426 "
Difference surface of water in pump well, and cent. water-pressure gauge	14.483 pounds.
Allowance for extra frictional resistance of water passages into and out of pumps	1.00 "
Total head pumped against during test for fire purposes	129.548 "

With a constant steam pressure of 70 pounds, and a

boiler capacity sufficient to furnish the required amount of steam, the engine—with the addition of the bye-pass to take steam direct into the low-pressure cylinder—will readily work against a total pressure for fire purposes of 130 pounds from surface of water in pump well, at 130 feet piston speed, or at the rate of 3,000,000 gallons per diem of 24 hours.

The indicator diagrams taken during the trial were scaled and worked with the following average results:

Diagrams from each end of each cylinder	25
Average initial pressure, high-pressure cylinder, above atmosphere	70.49 pounds.
Average cut-off in decimal of stroke, high-pressure cylinder	0.32815
" terminal pressure, high-pressure cylinder, above atmosphere	17.54 pounds.
Average counter pressure at mid-stroke, high-pressure cylinder, absolute	11.145 pounds.
Average initial pressure, low-pressure cylinder, above atmosphere	5.6125 "
Average terminal pressure, low-pressure cylinder, absolute	7.598 "
" counter " " " " "	3.29 "
Effective vacuum	11.175 "

The compound diagrams, of which engravings are presented, were worked from the diagrams taken at 1 P. M., March 9th, 1886, the originals of which are also engraved and submitted.

In the original compound diagrams, from which the engravings are reduced, the vertical scale is 16 pounds to the inch, while the horizontal scale is constructed upon the basis of 7 inches, representing the sum of the volumes of low-pressure cylinder, its clearance, and the clearance of high-pressure cylinder, which is the volume the steam occupied at the end of expansion.

The curves constructed upon all the diagrams are isothermal or Mariotte curves, which usually agree more nearly with the actual curves of expansion of first-class steam engines, than the adiabatic curve—$p \infty v^{\frac{10}{9}}$.

The indicator springs, 40 pounds for high-pressure cylinder, and 10 pounds for low-pressure cylinder, were carefully tested for pressure readings, together with the water-pressure and steam-pressure gauges. No facilities

Kalamazoo, Mich. 1:00 P.M. March 9, 1886.

H. P. Cylinder.

40 Spring.

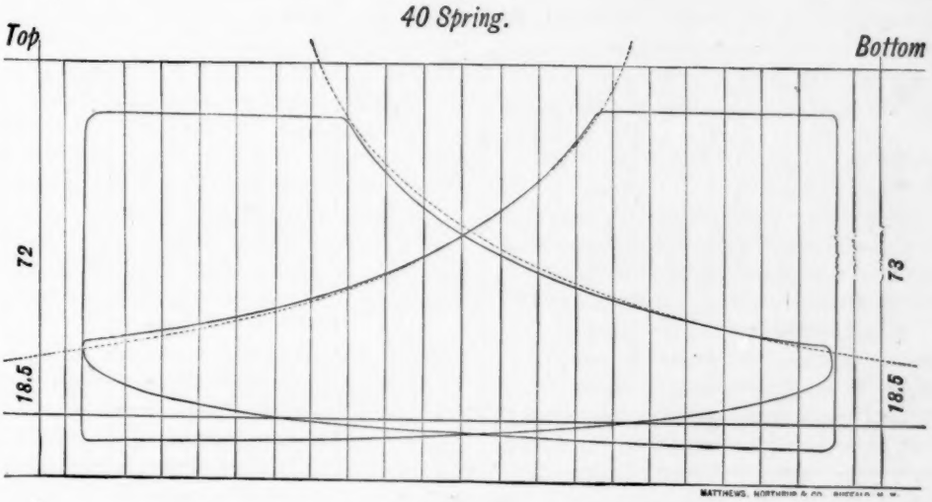


Fig. 5.

Mean effective pressure, high-pressure cylinder, top	46.668 pounds.
" " " " " " bottom	48.452 "
" " " low-pressure cylinder, top	7.583 "
" " " " " " bottom	9.164 "
Total horse-power developed	81.891
Ratio of expansion by pressure	11.18
" " " " volumes	12.03
Coal, per indicated horse-power, per hour	1.78
Steam, per indicated horse-power, per hour	17.33

Comparing the moments of load of the steam pistons and water plungers during duty trial, we have:

High-pressure cylinder, top	$254.47 \times 46.668 = 11875.6$ pounds.
" " " bottom	$(254.47 - 5.412) \times 48.452 = 12067.36$ "
Low-pressure " top	$1017.9 \times 7.583 = 7718.73$ "
" " " bottom	$[1017.9 - (2 \times 9.28)] \times 9.164 = 9157.95$ "

Average moment steam pistons,

$$\frac{11875.6 + 12067.36 + 7718.73 + 91.57.95}{2} = 20409.82 \text{ pounds.}$$

The average moment of load of water plungers during duty trial was $315.1425 \times 59.8384 = 18857.623$ pounds, and percentage of useful effect realized in the work of the pumps:

$$100 \times \frac{18857.623}{20409.82} = 92.395,$$

leaving 7.605 per cent. of the total power of engine to cover the losses of friction.

were at hand to test the springs used on the low-pressure cylinder for vacuum readings, and it is possible, and, in fact, likely, they were somewhat in error, but not enough to affect the action of the steam, as shown by the compound diagrams.

The boiler furnishing steam to the engine is of the following dimensions:

Diameter of shell	60 inches.
Length of shell	16 feet.
Number of tubes	70
Diameter of tubes	3 inches.
Heating surface, shell	125.644
" " tubes	879.648
" " heads	16.199
Heating surface, total	1021.511 sq. ft.
Grate	$4.17' \times 2.7'$
Grate surface	11.3 square feet.
Tube vent	2.63 " "
Ratio heating to grate surface	90.4
Ratio grate surface to tube vent	4.296
Chimney, brick	$3.5' \times 3.5'$— 110 feet high.
Cross section of chimney	12.25 square feet.
Ratio grate surface to cross section of chimney	0.9224

During the duty trial, the coal was burned at the rate of

$$\frac{3500}{24 \times 11.3} = 11.235 \text{ pounds}$$

per hour, per square foot of grate surface.

No measurement was made of the water pumped to the boiler, because the duty terms of the specification and agreement required the economy of the engine to be calculated from the actual consumption of coal, without reference to the economy of boiler, and the work of the boiler cannot, therefore, be stated with any degree of exactness; but, as an approximation, an estimate was made of the evaporation, from the weight of steam found at release in the low-pressure cylinder, upon the assumption that 80 per cent. of the total steam would be accounted for by the indicator diagrams.

Volume of low-pressure cylinder per hour,

$$\frac{1017.9+999.34}{144} \times 2.5 \times 26.5292 \times 60 = 55743.156 \text{ cubic feet.}$$

Volume of clearance per hour; $0.025 \times 55743.156 = 1393.576$ cubic feet. Weight of steam, per cubic feet, at terminal pressure in low-pressure cylinder (7.598 absolute)=0.0201 pound, and weight of steam to release in low-pressure cylinder, per hour; $55743.156+1393.578 \times 0.0201 = 1148.448$ pounds. Less steam retained in clearance upon closure of exhaust: weight of steam at counter pressure in low-pressure cylinder (3.29 absolute)=0.009328 pound.

$1393.578 \times 0.009328 = 12.999$ pounds, and steam accounted for $1148.448 - 12.999 = 1135.448$ pounds, and probable hourly evaporation by boiler,

$$\frac{1135.448}{0.8} = 1419.31 \text{ pounds.}$$

The coal was burned at the rate of $\frac{3500}{24} = 145.83$ pounds per hour, and steam, per pound of coal,

$$\frac{1419.31}{145.83} = 9.733 \text{ pounds.}$$

The setting of the boiler, and the slow rate of evaporation, would suggest a very small or no entrainment of water in the steam.

From this evaporation the "duty" of the engine was 103,000,000 foot pounds, in round numbers, corresponding to a "duty" of 105,826,000 foot pounds per hundred pounds of coal, upon an evaporation of ten to one, which is a basis of estimate for "duty" now frequently adopted in contracts for pumping engines.

Kalamazoo, Mich. 1:00 P.M. March 9, 1886.

L. P. Cylinder.

10 Spring.

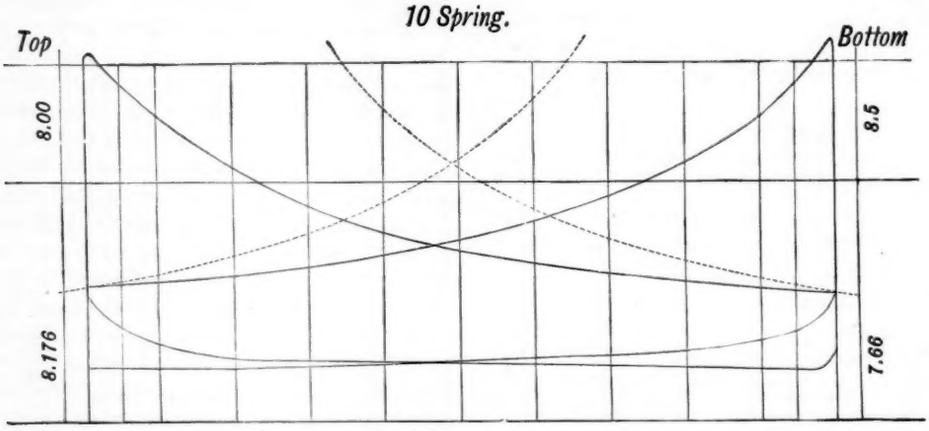


Fig. 6.

PATENTS.

BY A. K. MANSFIELD, M. E.

THE United States alone is now issuing at the rate of from 2,000 to 3,000 patents per month. This represents an outlay on the part of inventors, in fees to the government, as per the last annual report of the patent office, of about $100,000 per month. Add to this a fair average for fees paid to attorneys for the prosecution of ordinary cases, which may amount to about the same as the fee to the government, the sum becomes $200,000. The additional cost of prosecuting the more complicated cases may easily swell this figure to $300,000, which will represent the amount now being expended by inventors in the bare act of securing from the United States certified papers, with blue-ribbon attachment, which purport to grant them monopolistic privileges.

Of what value are these papers? This, of course, depends in the first place on the value of the invention in itself; but it depends, moreover, to a very important extent on whether the papers actually secure to the inventor the rights to which he is entitled.

According to the rules of the patent office, anybody may prosecute an application for a patent, either the inventor himself or whomsoever he may appoint to act as his attorney. No admission to the bar, nor course of mechanical study, nor special preparation of any kind is required by law, rule, or precedent. It follows that throughout the country men ply the avocation of "patent attorney" to the defeat of inventors. It is needless to say, there are reliable men in this calling; we are dealing at present with the evils of the system.

As a rule, the inventor of a machine knows only that he has devised a certain means which produces a certain end. To what extent the law is ready to allow him a monopoly in the field of his effort, is a matter for his "attorney" or "solicitor" to discover, with such aid or

hindrance as may be afforded by the Commissioner of Patents, or his assistants.

A great many patents are issued on inventions which are unlikely ever to be of much, if any, service to the public; but aside from this, it is safe to say, that the majority of patented inventions which may be of use to the public are covered by papers so poorly prepared that the rights of the inventor under them have very little worth. This is due to lack of skill, or to indifference, or both, on the part of "attorneys," and there can be no reasonable doubt that the possibility of such results is born of a defective system.

Most mechanical inventions have an underlying principle (that is, a principle not self-evident); if not, they would not be inventions, but mere aggregations of familiar parts not the result of inventive skill. The law is clear that a principle is not patentable; nevertheless, the law of equivalents, which secures to an inventor equivalent combination to that which he has devised, may be used to secure the monopoly to the inventor to which his discovery of a new principle entitles him. It generally requires a keen mechanical judgment to determine the principle or spirit of such an invention, and a careful analysis of the device, in the form in which it comes to the attorney, must be made, and various equivalent forms constructed in the mind in order to be able to express this principle in such language as to secure the rights to which the inventor is by law entitled. This kind of judgment is usually not possessed by an inventor, nor is it an attribute of a lawyer, nor does it come from experience in writing formal specifications. It is rather the outcome of a broad experience in and study of the science of applied mechanics. Certainly, a reasonable familiarity with legal decisions in patent causes is also an essential accomplishment.

It has come to be almost an axiomatic phrase that a patent possesses no value until it has been proven in the courts; so much so, that it has been seriously proposed that patents be always allowed when applied for, without examination into the merits of the case. This is so contrary to the apparent necessities of the system as to meet with very little approval among inventors. What we need is a more conscientious and skillful method of prosecuting applications under the present laws. How can this be arrived at? The only direct and reasonable way seems to be through the establishment of educational institutions, or through the introduction of special courses in existing institutions, which shall be designed to fit men for the specialty of patent attorneys. Laws would then need to be framed to exclude men not thus specially fitted from practicing this profession.

A dignity would thus be added to the profession, which it now lacks, and inventors would be better able to secure their legal rights without resort to expensive litigation, and would be able to obtain beneficial advice from their attorneys.

Let it be understood that these remarks do not apply to design patents, trade-marks, and the like, which are in the nature of copyrights, but to machinery patents, which constitute a large majority of all patents.

Under the system proposed, a patent attorney would be more nearly what is now known as a mechanical expert, and in place of doing the "no patent, no fee" style of business, which is often seen advertised, would be in a position to advise with his client as to the value, scope and validity of the papers which he has procured or might be able to procure.

Inventors are frequently most anxious as to whether a patent can be procured on the device which they have perhaps labored hard to produce. It is of far greater importance to know whether the patent which can be procured (for under the present system nearly anything possessing a number of parts can be patented,) will have any considerable value in the light of what has previously been done in the special art to which the invention pertains; also, to feel certain that whatever novelty exists shall be secured.

The matter of seeking for the underlying principle of an invention, and so setting it forth in the specification as to cover all equivalent methods, is of much greater importance than is usually supposed among inventors and patent solicitors.

To illustrate, an inventor applies a novel and useful device to an engine of a certain type. The device is equally applicable to engines of various other types. His attorney should have the mechanical knowledge and skill to perceive that the machine, as built by the inventor, is merely the illustration of a principle which the inventor has conceived, and should so compose the specification as to cover the combination of the device with all types of engines to which it can be usefully applied. Instead of doing this, the claim covering the device is made to read thus:

"In combination with a pair of vertical single-acting steam cylinders, a crank-shaft arranged to one side of the axial lines of such cylinders, with direct connection from each piston to the crank-shaft, substantially as set forth." If the word "vertical" had been omitted, and the words "out of intersection with" substituted for "to one side of," the point would have been covered.

Another inventor makes the application of an automatic governor to a particular type of engine, which is an original and useful application. The solicitor sees in this merely a complicated combination of parts, and expresses the invention in these terms:

"The combination, substantially as described, for actuating the auxiliary or cut-off valves G G′ by means of the governor K, it consisting in the cylindrical tube n^2 (fastened to the main valve and opening into the exhaust-chamber k' thereof by the passage o^2), the cylindrically-chambered boxes q^2 r^2 (applied to the valves G G′ by means as described), boxes w^2, the two shafts x^2, their forks y^2, and dogs z^2, the tappets d^3 (having curved arms e^3 and projections h^3), spring g^3, stops i^3, stud f^3, slide k^3 (provided with the friction-roller n^3), slotted slide p^3 (having an arm r^3), connecting-rod s^3, bell-crank t^3, arm u^3, and rod v^3, the latter being pivoted to the sliding sleeve w^3 of the governor K, and all being arranged and to operate essentially as represented."

It need hardly be pointed out that such a claim as this is of practically no value, owing to its extreme complication. It may be admitted that the law would render all liable who should make an exact copy of this machine, but no skillful mechanic would care to make such, when, as in the present case, an indefinite number of combinations can easily be made which accomplish the same result, and which the law would consider equivalents if the inventor had but made his request in proper form. The above are from actual specifications written by attorneys of note.

The law provides that the patent which an inventor accepts represents the whole breadth of his invention. How important, then, that the case shall be so prosecuted that the inventor may have the full benefit of the law.

In the process of prosecuting a patent application in this country, the inventor is plaintiff and the public defendant. The former may be represented by a solicitor, and the latter is represented by the Commissioner of Patents and his assistants. The case, on the part of the defendant, is often conducted with great skill; and at other times unnecessary obstacles are thrown in the way of the inventor, or, through an honest misunderstanding of the merits of the case, it is very difficult to obtain the rights to which the inventor is entitled. In any or all of these difficulties, the quickest and easiest method is to waive the actual merits of the case and accept the dictum of the patent office; yet a more difficult and slower course should commend itself to inventors.

Capitalists, as well as inventors themselves, are often at a loss to determine from the papers representing a patented machine whether the invention has any practical value in the light of what has been done before. A common way of determining this is by defending the patent before the courts, at great expense, if not with defeat. This may often be avoided by placing the matter in the hands of a skillful expert for investigation, before investing in the patent. A thorough study of the state of the art, as shown by the patent records, will enable him to report to what extent it advances the art to which it appertains, also whether it infringes any existing patent, as well as whether it represents the actual invention of the patentee. A full investigation of these points will often bring to light totally unexpected information, placing the value of the patent on an entirely new basis, and enabling the inventor and the capitalist to conclude understandingly whether it is desirable to "work" the patent. Such an investigation may save many dollars in costly suits at law.

It is frequently the case that a critical analysis of an invention will disclose to the eye of an expert various other methods of solving the same problem, which would not pass under the law for equivalent methods. The method developed by the inventor may indeed be the most direct, yet if capital is at stake in developing the invention, it is important to exclude competition from the particular field to which the invention appertains. This may be done, to a great extent, by having a systematic study of the field made, by one skilled in such a pursuit, for the purpose of strengthening the original patent by taking out other patents of a secondary nature. This important matter is very often neglected, a common reason being that the vanity which often accompanies the faculty of invention leads the inventor to believe that his invention is invincible. When the patent begins to realize financial success, however, to such an extent as to force itself on the attention of the public, other inventors of equal, or possibly superior, capacity are led to examine the papers and inquire into the state of the art. Then it is that the secondary patents play their part.

It is the fashion of a good many patent attorneys to end the explanation of an invention with a tedious number of claims, many of which are of no possible help to the scope or value of the patent. The claims of a patent are expressed for the purpose of making it clear to the public exactly what features of the apparatus illustrated and explained are held to be original with the inventor. These claims are of two kinds known as generic (broad, or relating to the principle or spirit of the invention), and specific (relating to the special combination of parts). Patents are not often seen with too many of the former kind of claims, for it requires skill to write them properly and exactly; but it is easy, and requires very little mental exertion, to construct combination claims embracing a multitude of parts, and the greater the number of parts the less the liability of their ever having been combined in the same manner before, and the less the liability of anybody ever desiring to combine them in the same manner again, therefore, the less they add to the value of the patent. In fact, it may be urged that a majority of the lengthy combination claims, seen in many recent patents, have a tendency to weaken the force of the patent in the courts, and it is quite certain that many of them ought to be rejected at the patent office (instead of meeting with high favor there, as they appear to) on the ground of not having required inventive skill. The writer holds that it does not follow from the fact of a patentable combination having been discovered, that the combination of this device with other well-known parts is also necessarily a patentable novelty, for such a combination as this latter may be merely the result of ordinary mechanical skill. Yet innumerable claims of exactly this nature are allowed by the office; whether justly or otherwise, it is certain that many of them do not add at all to the value of the patent. A fair illustration is the latter of the two claims quoted above.

A great army of men is at all times seeking the glory and reward of invention. There still remains endless opportunity, but, in this as in other fields, the great prizes are for the few only. Of those who fail to realize expected results, some become morbid and visionary, others continually work in impracticable fields, others make good beginnings but leave the rewards to more steadfast workers. These facts have brought the art of invention into disrepute, and all patented inventions are viewed by some people much as if they were the schemes of impracticable fanatics.

If it be considered, however, how many great mechanical industries have been built up and are now prospering, founded on the monopoly which patents grant; what a vast number of labor-saving and life-saving machines owe their existence to the exhausting toil of inventors, the conclusion must follow that one of the most valuable resources of the American nation is its unparalleled faculty of invention.

HOW TO RUN A LOCOMOTIVE.

BY RICHARD H. BUEL.

THE motor of a locomotive consists, essentially, of a pair of non-condensing steam-engines, with adjustable cut-off controlled by hand; the engines being supplied with steam from a high-pressure boiler. Steam of exceptionally high pressure is carried in locomotive boilers, for a double purpose: primarily, in order to reduce the weight of boiler and engines; and also for the purpose of producing the necessary power with a minimum consumption of coal and water.

The nearest counterpart to the locomotive, in stationary motors, is the modern non-condensing automatic cut-off steam-engine, using steam of high pressure, but with the important difference that, in the stationary motor, the governor automatically controls the speed and power of the engine; while the action of the locomotive engine is controlled by the runner, who can, at pleasure, regulate the speed and power of his engines, either by changing the point of cut-off or by admitting more or less steam to the cylinders through the throttle-valve. Now, since the stationary engine, to which reference has just been made, is commonly regarded as the most economical type of non-condensing steam engine in use at present, and the locomotive engine possesses nearly all the features of the former motor, it seems reasonable to suppose that, were the locomotive runner to control his engines as skillfully as the automatic cut-off engine is regulated by an efficient governor, the locomotive would be run in the most economical manner. It may be useful, then, to briefly consider the action of the stationary engine, and see how nearly the same action is possible for the engines of the locomotive. Generally speaking, the principal requirements for either the stationary engine or the locomotive engine are as follows: To start from rest and attain the required speed in the shortest possible time, and to maintain this speed as nearly as possible under varying loads; always producing the necessary power with the greatest economy attainable under the given circumstances.

In starting such a stationary engine as the one under consideration, the engineer opens the throttle-valve, by degrees, until the governor commences to actuate the cut-off gear, when he opens the valve wide, and leaves it in this condition until he wishes to stop the engine—unless, at any time, the load becomes so light that the speed cannot be controlled at the shortest point of cut-off, in which case it becomes necessary to partially close the valve and throttle the steam. When the engine is running, with the throttle-valve wide open, and the load is suddenly increased, the governor, if efficient, immediately adjusts the point of cut-off so as to give a longer steam-admission, and maintains the cut-off at this point until the load is diminished, when the point of cut-off is at once shortened so as to prevent an increase of speed. Such a method of running an engine seems to be very reasonable. Having generated steam of high pressure in the boiler, good sense would seem to dictate that the engine should receive the benefit of this pressure, and that it would not be very commendable practice to reduce the pressure by throttling the steam before admission to the cylinder—unless the speed of the engine could be controlled in no other way. But such throttling is only too common, in locomotive running, even by runners of great experience—with the result of an unnecessary consumption of coal and water.

Possibly, the foregoing remarks will be sufficient to convince some engineers that the most economical method of running any engine, locomotive, stationary or marine, is to admit steam of boiler-pressure to the cylinders, and control the speed by regulating the amount of steam admitted at each stroke—under the supposition, of course, that the engine is properly proportioned and adjusted for its work—but others may like to see experimental data on the subject.

Some time ago, the writer made a number of tests with locomotives, drawing light trains and stopping frequently; the tests including measurements of coal and water consumption, speed of engines, boiler pressure and power exerted, together with observations of every change in positions of link and throttle-valve. These experiments, being conducted with several locomotives, under the management of a number of experienced runners, furnish data of considerable interest in relation to handling a locomotive engine.

Fig. 1 shows two indicator diagrams from a locomotive, illustrating, graphically, two methods of running, one economical and the other wasteful. The locomotive was

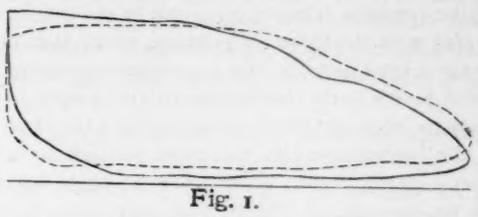


Fig. 1.

doing about the same work, in the two cases, as appears from the following data:

		Diagram in full lines.	Diagram in broken lines.
Lbs. per square inch above atmosphere.	Boiler pressure	121	125
	Average back pressure.	7.5	13.2
	Indicated pressure.	75	73.2
	Release pressure	33.2	48.6
Revolutions per minute		190	193
Link (point of cut-off marked on quadrant)		8	12
Position of throttle-valve		Fully open.	Half open.
Weight of a cubic foot of steam at release pressure, lbs		0.1160	0.1504
Ratio of weights		1	1.3

Judging from these diagrams, the locomotive engine was using about 30 per cent. more steam in the second case than in the first, to produce about the same power. This, of course, is only an approximation, since more steam is always used by an engine than is shown by the indicator diagram; but it must be evident that the steam consumption is much less, in the case of the shorter cut-off and open throttle-valve. In the table which follows, this point is further illustrated. The results in the table are for runs of one hundred miles each, made by different locomotive runners; and in each experiment marked "preliminary," the management of the engine was left to the runner, while in the runs marked "regular," the runners were required to keep the throttle-valve fully open, except when the speed became too great, and regulate the admission by the link. In the "preliminary" runs, the steam was almost invariably throttled to some extent, and the cut-off was correspondingly lengthened—most of the runners apparently considering this method to be the best. Although a large number of experiments were made, only a few of the runs could fairly be called "preliminary," in the sense which has just been explained; because locomotive runners, as a class, are men of more than ordinary intelligence—and each runner being desirous of showing the most economical results, the old method of running was soon abandoned (during the experiments, at least) for the kind which is here classified as "regular."

The table, in addition to showing the great difference in economy between admitting steam of full pressure and throttled steam, illustrates further (by differences in results from the same locomotive on "regular" runs) the different degrees of skill displayed by runners acting as automatic governors.

ECONOMIC PERFORMANCE OF LOCOMOTIVES.

Number for reference.	Locomotive.	Boiler pressure, lbs. per sq. in. above atmos.	Lbs. of water per car-mile.	Remarks.
1	A	134	39.73	Preliminary run.
2	A	129	34.22	Regular run.
3	A	127	34.78	Do.
4	B	132	43.29	Preliminary run.
5	B	133	36.65	Regular run.
6	B	127	37.93	Do.
7	C	119	42.32	Preliminary run.
8	C	133	36.75	Regular run.
9	C	132	34.91	Do.

In one instance (experiment 7), it will be observed that the boiler pressure is much less than in the other two experiments with the same locomotive, which fact, of itself, may have a considerable effect upon the economic result. But this seems fairly chargeable to the runner, since it was easy to keep up the pressure in the other two cases, when the locomotive was run more skillfully—and it is axiomatic to say that a boiler may be large enough to supply an economical engine and may seem too small when steam is needlessly expended.

It would probably surprise any one, who had not previously investigated the subject, to see how general is the practice among locomotive runners of using throttled steam instead of steam at boiler pressure—and, of course, there must be some reason for the practice. As a matter of fact, there seem to be two prominent reasons: It requires more skill to run an engine by the link instead of by the throttle-valve; and when an engine is out of adjustment, the most economical method of running frequently becomes impossible.

If a locomotive engine is run by the throttle-valve, the runner has only to set the link so as to give sufficient admission for drawing a train over ordinary grades, and control the speed by opening or closing the throttle-valve. When he runs by the link, especially in starting the locomotive, considerable skill is required, to attain full speed in the quickest time, for the runner must move both link and throttle-valve, precisely as the stationary engineer and the governor together act in starting the automatic cut-off engine; and it requires rather more practice to vary the power by changing the position of the link, than by moving the throttle-valve lever. But our locomotive runners have sufficient skill to accomplish more difficult things than this manipulation, and the writer's experience convinces him that every runner who fairly tries the method of running by the link will scarcely go back to the more wasteful practice of running by the throttle-valve—unless the latter method becomes imperative, on account of faulty valve adjustment.

Valves out of square, that is to say, valve-motion so arranged or disarranged as to give very unequal admission at opposite ends of the locomotive cylinders, renders it necessary to run a locomotive in a wasteful manner; because the distribution of power is so unequal that a longer steam-admission must be permitted than would otherwise be the case. Hence, it becomes difficult to keep up the steam pressure, and the locomotive at once gets a bad name: the boiler will not make steam, the engine is out of line, the driving-axle boxes are badly worn, and the locomotive has all the maladies, according to the unhappy runner who finds it difficult to run on time. During the locomotive tests made by the writer, the locomotive considered to be the worst on the line was fitted up for experiment. This locomotive was the bugbear of all the runners: it wouldn't steam, they couldn't get any power out of the engine, they couldn't make time, everything was loose about the locomotive, etc., etc. After a thorough trial of the locomotive, with all its faults, the valves were squared, and no other adjustments were made. The following table shows that this simple change eradicated all the imaginary ailments:

PERFORMANCE OF LOCOMOTIVE BEFORE AND AFTER SQUARING VALVES.

Number for reference.	Steam pressure, lbs. per sq. in. above atmos.	Link (point of cut-off marked on quadrant).	Pounds of water per car-mile.	Remarks.
1	122	9-11	45.92	Valves out of square.
2	124	9-11	46.94	"
3	127	9-11	47.88	"
4	135	6-9	40.78	Valves squared.
5	133	6-9	40.03	"
6	132	6-9	39.99	"

In making very high speed with a locomotive, many runners have found by experience that it is not possible to run with the link very far down, and that the throttle-valve is only to be adjusted when the speed becomes excessive. Two diagrams from a locomotive with the

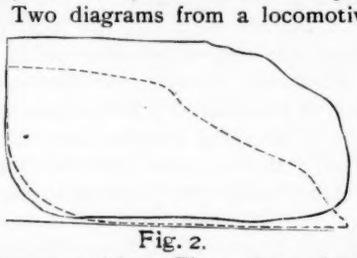


Fig. 2.

link in extreme positions, Fig. 2, show clearly that the steam can readily escape when the admission is slight, while the exhaust becomes choked and the locomotive "coughs," if the admission of steam is prolonged much beyond half-stroke. This action is not peculiar to locomotive engines. Nearly all cut-off engines have exhaust openings, sufficiently large to prevent undue back pressure, for cut-offs up to one-half or five-eighths of the stroke; but for longer admissions the openings have not enough area to permit of running the engines at full speed. Locomotive engines, and cut-off engines generally, are ordinarily proportioned so as to exert power enough for usual loads at points of cut-off not exceeding five-eighths of the stroke (and generally much less), so that, in the case of unusual loads, the engine speed is decreased. The greatest tractive force required of locomotives is in starting trains and in drawing trains over heavy grades. The diagram in full lines, Fig. 2, was taken on a steep grade, and the diagram in broken lines was taken on a level, with the throttle-valve partly closed for the purpose of reducing speed. Thus two diagrams were obtained, showing approximately the same power under very different circumstances. The principal data relating to these diagrams are as follows:

		Diagram in full lines.	Diagram in broken lines.
Lbs. per square inch above atmosphere.	Boiler pressure	125	127
	Average back pressure.	7	0.5
	Indicated pressure	100.2	66.6
	Release pressure	63.6	15
Revolutions per minute		98	140
Link (point of cut-off marked on quadrant)		11	5
Position of throttle-valve		Fully open.	Half open.
Weight of a cubic foot of steam at release pressure, lbs		0.1835	0.0742
Ratio of weights		2.49	1
Indicated horse-power		124.6	118.4
Tractive force from diagrams, lbs		4,100	2,731

In starting trains, and in drawing trains over heavy

grades, the locomotive runner must handle the engine with great skill, so as to avoid slipping the driving-wheels when starting, and slipping the wheels or "stalling" on grades. The diagram in full lines, Fig. 2, represents fair practice on the particular grade where the diagram was taken—a large number of obversations made on this grade showing a minimum speed of 40 revolutions a minute and a maximum speed of 124, these two extremes being results obtained by the least skillful and the most expert runners. In drawing trains over the grade, as well as in general running, the best results were obtained by those runners whose manipulation most closely resembled the automatic action of the governor connected with the cut-off gear of a stationary engine; lengthening the point of cut-off promptly as the load increased, and raising the link as soon as the load was lessened.

The questions treated in this article are well worthy the attention of railroad officials. The experiments made by the writer show that very considerable economy in drawing trains can be effected without making any change except in manipulation, and that locomotive runners can readily be induced to exchange a wasteful for an economical mode of running. Unless there is some serious fallacy in the observations, locomotive runners might well study the action of an efficient governor on an automatic cut-off engine, and then be sent to their locomotives with the injunction: "Go ye and do likewise!"

SHOP TOOLS AND MACHINERY.

The time is long since past when the hammer, chisel and file, in the hands of a skillful and ingenious mechanic, are sufficient to produce all the different parts of machinery. Such artisans are undoubtedly an honor to their craft, and most desirable in any shop, no matter how good may be the facilities provided, but their skill alone cannot supply the lack of good tools and bring about economical production. This is so well known, and so generally conceded, that reference to it would seem unnecessary; yet a glance at the number, kind and condition of tools found in some railroad shops, cannot but impress the observer with the conviction that the advantages pointed out, are in some cases either not understood, or entirely lost sight of. That reasonable economy in doing work is attained under such unfavorable conditions, is ample proof of the ability of the managers of such shops, but how much greater would be their success if good tools and appliances were placed within their reach? Workmen will perform their duties more cheerfully if some effort is made to provide them with a shop well lighted, ventilated and heated.. The enforcement of cleanliness and order will also result in greater economy. Dingy corners will not be ornamented with piles of material, good and bad. The space under each workman's bench will not be filled with miscellaneous parts, which are stored away because they may come handy some day. This system of storage is resorted to because workmen frequently experience difficulty in procuring what they may require for a hurried job. Each of these piles is considered private property, and therefore no other workman will attempt to select from it anything he may want.

The owner alone will overhaul it each time he has occasion to look for material, and thus lose valuable time. If he fails to find what he wants he will apply to the foreman for new parts, although many, such as he wants, may be buried in other piles a few feet from his bench. The money invested in this material would in many cases go very far toward paying for the erection of a good storeroom where the necessary stock could be intelligently kept and assorted, and thus, also, save much time and therefore money by preventing delays in procuring material. The absence of a first-class tool room, and of a system requiring tools to be kept in it and issued from it, is also attended with greater extravagance and loss than is supposed by many who have had no experience in shop practices. Let the contents of each workman's drawer be examined, and in each will be found an assortment of wrenches practically alike, any of which might be used by other workmen.

Some of these may have been made for special work seldom repeated by the same man, but perhaps done occasionally by others. These are also considered private property and therefore will be duplicated some time at great cost by others, because they have no access to tools in the possession of their neighbors. The same is true of many other tools made for special work also, which will be duplicated again and again, and similarly kept out of sight by the workman, who thus practically becomes the owner. The number of cold chisels, of every conceivable shape, scrapers, files, taps, reamers etc., will be found astonishingly large and far in excess of actual requirements. The workman cannot be blamed for this extravagant accumulation. He is hired to do certain work, and if he finds that his employer shows little regard for his interest, by failing to provide a place from which he may procure the necessary tools with which to do his work promptly, and thus save him delay and annoyance, he takes the only sensible course. Cost what it may, he makes sure to provide himself with all necessary tools, and he sees that they are carefully stored and cared for until he again requires them.

We recall some incidents connected with the work of reorganizing a tool room in a shop employing a large number of men. The stock of tools was very limited and it was proposed to make necessary increases. It seemed impossible, however, that the amount of work actually turned out could have been done with the stock of tools in the tool room. The conclusion was reached that large numbers of these must be in possession of the workmen. Therefore it was deemed best to examine the contents of each drawer, and to transfer to the tool room all such as were not actually required by each workman. Drawer after drawer was inspected, and ample stock left in each, and the surplus put in a wheelbarrow, which was repeatedly emptied and refilled. Many of the last drawers examined, contained only the ordinary complement of tools, which seemed rather singular. However, nothing was said at the time, but shortly after the search was renewed, beginning with the end of the shop which on the previous occasion was examined last. The stock of tools had grown considerably in that short space of time. The surplus was again taken to the tool room, and when assorted it was found that no increase in the stock was required, but on the contrary a large excess remained, sufficient to replace similar tools, as they became worn, for quite a period of time. It was arranged to have all tools worn, or requiring dressing, taken to the tool room where others in good order were given in exchange. The worn tools were sent to the smith shop and again

returned to the tool room after being repaired, and not replaced upon the shelves until they were ground, or otherwise put in good condition. In addition to the large saving of valuable material, it was found that tools could be kept in excellent order even after one smith and his helper were removed from the tool-dresser's force.

It must be evident that the cost of a suitable tool room, and the expense of introducing and maintaining a system which would make this room a center for the manufacture, repair and custody of all tools required by the workmen, would be soon repaid by the saving in a large amount of costly material and labor entering into the manufacture of the excessive and unnecessary number of tools which are otherwise likely to be carried. The item of labor will be materially decreased if the tool work is placed in charge of expert mechanics, who can certainly produce more cheaply than other workmen who are inexperienced in this particular branch of the business. The maintenance of standard sizes and shapes, the importance of which cannot be overestimated, is possible only when this work is carried on under such a system. Interchangeability of parts of locomotives cannot be attained, unless the manufacture of templates for laying out, drilling or finishing them, is restricted to competent specialists.

To enable such workmen to accomplish these important results, machinery of the latest and most improved design should be provided. Antiquated machines are not economical and cannot produce accuracy in the manufacture or maintenance of tools.

This class of machine tools is equally out of place in other shops. Economy in production, and accuracy in finishing is impossible on many such as are so frequently found in shops. Take for instance an old planing machine, with a short table and one cutting-head. Very few pieces can be finished upon it at one operation. If four sides must be planed, four settings are necessary, involving great loss of time. On a good modern machine, with a longer table and four cutting-heads, a greater number of pieces can be finished at one time, and the number of changes to bring the surfaces to be planed to proper positions are very much reduced. We have seen locomotive frames planed on short planing machines, which made two settings necessary to plane each side, besides resetting for the top, and the bottom of pedestal legs. The work of slotting the pedestals, and other parts of the same work, is not rarely done on a single slotting machine requiring a change of position for each pedestal in order to bring it to the cutting tool. The loss of time which such tools involve is considerable. The greatest porting the portion overhanging the table, in order to care must be exercised in setting and clamping, and in supobtain any degree of accuracy in finishing these parts. This is most difficult to accomplish, since the supports often rest upon a bad and unsteady floor, which is badly shaken even by the weight or motion of a passing wheelbarrow. These difficulties would not exist if one of the modern slotting machines, with fixed table and movable heads, were used instead. Besides insuring accuracy in finishing, the cost of the work would not be one-fourth the amount that it would be if done on the other machine.

Slotting machines of insufficient stroke may be unprofitably used from day to day because only one or two pieces can be finished at one time, when a larger machine would enable twice or three times the amount of work to be done at one setting. An old lathe may often be found, used as a boring machine. Work cannot be done accurately on this except perhaps by the most expert, careful and high-priced machinist. A modern horizontal boring and drilling machine would do such work at much less cost, and with far less risk of spoiling it or of finishing it inaccurately, even when attended by an ordinary machine hand. Many parts are finished on small, antique shapers, with chisel and file, which might be finished for a trifling sum on one of the excellent milling tools now manufactured. Some boiler shops, in which new boilers are made and fire-boxes renewed, are remarkable for the absence of suitable tools. Rolls will be seen wholly unfit, either from their size or condition, to shape the sheets properly, Punches in the same condition and capable of punching only a few holes, making the drilling of many necessary.

Stay-bolts are tapped by hand at great expense, when the cost might be reduced immensely by the use of the flexible shaft, which can be obtained at a very moderate cost.

Riveting is perhaps done by hand, the cost of which might also be reduced nearly ten-fold by the use of a riveting machine. In the smith shop may perhaps be found an old steam hammer, designed years ago for work of a character totally different from present requirements. On account of limited range it cannot be used for most important work, and from old age it may be out of service, while undergoing repairs, a considerable portion of the time; the cost of which and the value of time lost on account of such delays can scarcely be calculated. A bolt-header of insufficient size and capacity may also render it necessary that many bolts of large size be made by hand, at a cost three or four times greater than they could be made for on a suitable machine. The failure to provide good forming and bending tools will also compel such work to be done by hand at great cost.

The argument may at once be advanced that such tools cost a considerable amount of money, and on that account are beyond the reach of any but wealthy companies. That is true as to the cost; but we would answer that the old machine tools increase the cost of production immensely, which cost, added to the expense of keeping them in running order, would not only pay the interest on the necessary investment for new tools, but would leave a large surplus, in addition, which would bring back a portion at least of the amount thus invested.

If the expense of equipping all the shops of a railroad company would be too great, perhaps one so equipped would be found to answer every purpose. by concentrating as much of the work as possible in that particular one. We may safely say that a careful investigation of this subject will lead to the conclusion that many tools which are tolerated in shops, would be more profitable in the scrap-heap than to retain them in service.

ALTHOUGH rear collisions have happened on the New York elevated road, crossing collisions have been exceedingly rare. The first serious one happened on January 19, when a Second avenue train struck a Third avenue train at the Chatham square crossing, badly damaging the rear car, which had, fortunately, very few passengers in it. The accident, it is stated, was due to an engineer who ran past a signal which was set against time. The number of trains at this crossing is very great, and a constant vigilance is required to prevent accident.

Selected Articles.

On the Friction of Non-Condensing Engines.*

BY R. H. THURSTON, ITHACA, N. Y.

THE assumption of the distinguished engineer, De Pambour, that the wasteful resistance of a steam engine consists of a constant quantity, the friction of the unloaded engine, increased by some increasing function of the added load, has been accepted as correct by probably all recognized authorities since his time. Calling R_0 the resistance of the engine running free and under no other load than its own friction, and calling R_1 the resistance coming upon it as a useful factor of its work, and making f the co-efficient measuring the proportion of increased friction due to the load, the total resistance to be overcome by the engine piston is thus

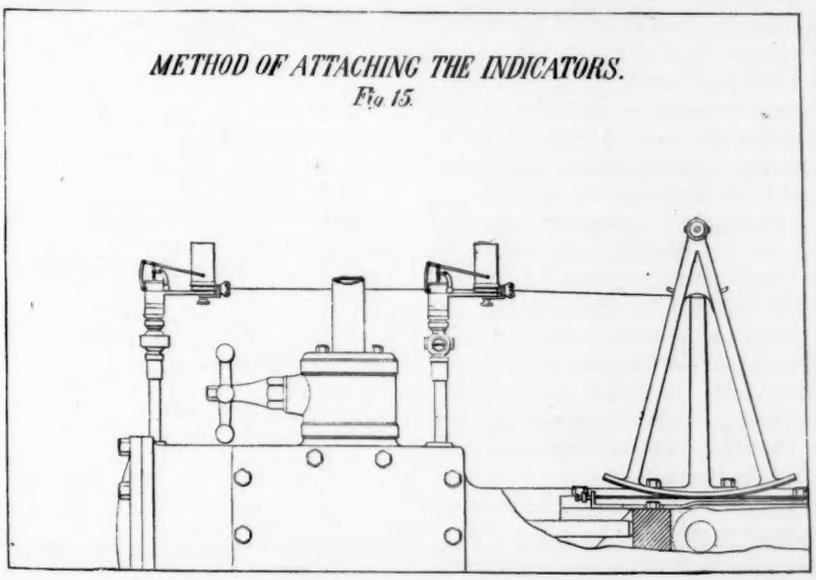
$$R=(1+f)\,R_1+R_0. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1.)$$

So far as the writer has observed, it has never been questioned whether the quantity f is constant or variable, and no recent attempts have been made to ascertain its value by experiment.

It has long been the intention of the writer to settle this question, which had for years existed in his own mind, and the opportunity has recently been offered to do so, at least as that question affects the modern forms of non-condensing, high-speed engines now so generally in use, especially for electric-lighting purposes. The first investigation was made, at the suggestion of the writer and under his general direction, in the winter of 1883–4, upon a "Straight Line Engine," exhibited that year at the Annual Exhibition of the American Institute, by the Straight Line Engine Company, of Syracuse, N. Y., and built by them from the designs of Prof. John E. Sweet, the inventor of its special features.† The results were sufficiently exact and satisfactory in every respect to have been made the basis of the conclusions here to be stated; but it seemed to the writer desirable that they should be checked by similar work upon another engine, if possible of a different make, before attempting to state definite conclusions of any kind. The opportunity to secure such a repetition of the investigation was offered, during the past winter, at Cornell University, using a "Straight Line" engine, which could be fitted with a brake, and conveniently submitted to test. The engine is of the same make as the first described, but of a different size, and the results of the two sets of experiments are considered to accord so thoroughly as to justify publication. The following are the data and results of these two sets of determinations:

The first of these two engines was built from designs brought out in the year 1880, of which illustrations may be seen in the *Electrician*, of December, 1883. As is well known, the engine derives its name from the fact that, in its design, the attempt has been made to take all stresses through straight members, the frame thus being made to consist of two straight compression and thrust members, connecting the cylinder heads directly with the main pillow-blocks, and giving a characteristic appearance to the whole machine. The valve-gear is of the "positive" type, the expansion made variable by the introduction of a governor on the main shaft actuating the eccentric, in the manner familiar to all who have seen the more common forms of high-speed engines. In the design of this governor, as throughout the whole engine, special care has been taken to provide against the impeding action of friction, the machine being intended to be as nearly frictionless as possible. The engine rests upon three points of support, and thus is not liable to be thrown out of line by any inequalities of foundation or bolting. When tested, the engine to be experimented with was simply set on blocking, and had no foundation; but so well was it balanced, and so perfectly was its alignment maintained, that it ran with absolute smoothness, and as steadily as if it had been given the heaviest foundation possible.

METHOD OF ATTACHING THE INDICATORS.
Fig. 15.



For the purposes of test, it was fitted with a pair of carefully standardized indicators and a Prony brake. Cards were taken simultaneously from both ends of the cylinder,

* Paper read at the meeting of the American Society of Mechanical Engineers, held in New York.

† The work was done with equal care and skill by Messrs. Mitchell and Aldrich, graduates of Stevens Institute of Technology, of the class of 1884.

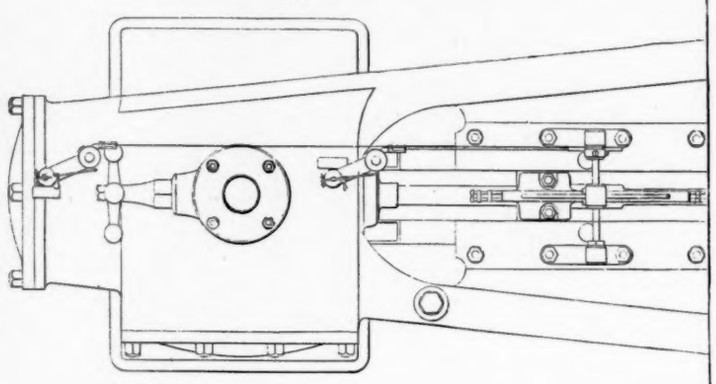
and, at the same instant, readings from the brake were obtained. A comparison of the power indicated by the diagrams and that shown by the brake gave a difference which measured the friction of the engine. During the trial, the engine, when working at its rated power, consumed, according to the indications of the diagrams, 28.2 pounds of steam per horse-power per hour, or, probably, between 35 and 38 pounds, allowing for the loss by cylinder condensation, not accounted for on the indicator card, a very excellent performance for an engine of but 35 horse-power. The action of the governor was extraordinarily perfect. The engine was adjusted to make 230 revolutions per minute under 90 pounds steam pressure. The observers reported that it made the same number of turns whether loaded or unloaded, an evident impossibility with a governor of this class, in which only approximate isochronism can be attained. The writer, to settle the question, counted the revolutions, minute by minute, with a hand-speed counter, and made it 230 revolutions with

tween centers, a balanced valve with stroke of 2 to 4 inches, according to position of governor and eccentric, a fly-wheel 50 inches in diameter, weighing 2,300 pounds, the steam and exhaust-pipes having diameters of 2½ and 4 inches, respectively, and the whole machine weighing 2½ tons. The space occupied by the engine was 9 feet 4 inches in length, by 4 feet 8 inches in width, and 3 feet 10 inches in height.

Examining the above table of powers, it is seen that the difference between indicated and dynamometric power, the friction of the engine, varies somewhat, with varying steam pressures and varying total power; but in such manner as to indicate the controlling cause to be irregular in action, and possibly to some extent due to errors of observation and to accident. The maximum is four horse-power, the minimum about two horse-power. The usual difference is about three and the variations are irregularly distributed throughout the whole range of experiments. It is evident at a glance that the law of De Pambour does

METHOD OF ATTACHING THE INDICATORS.

Fig 16



the whole rated load on the engine (35 to 40 horse-power), and 231 when entirely unloaded, the brake-strap being loosened until it could be shaken about on the pulley, by the hand, with perfect ease. This was repeated until no question could longer exist in regard to the matter. The variation with variable steam pressure was greater.

The following are the data obtained from the brake and indicator readings:

Number of Card.	Revolut'ns.	Steam Pressure.	Brake H. P.	Indicator H. P.	Diff.	Friction per cent.
1	232	50	4.06	7.41	3.35	45
2	229	65	4.98	7.58	2.60	34
3	230	63	6.00	10.00	4.00	40
4	230	69	7.00	10.27	3.29	32
5	230	73	8.10	11.75	3.65	32
6	230	77	9.00	12.70	3.70	29
7	230	75	10.00	14.02	4.02	28
8	230	80	11.00	14.78	5.78	25.5
9	230	80	12.00	15.17	3.17	21
10	230	85	13.00	15.96	2.96	18.5
11	230	75	14.00	16.86	2.86	17
12	230	70	15.00	17.80	2.80	15.75
13	231	72	20.1	22.07	2.06	9
14	230	75	25.00	28.31	3.36	11.75
15	229	60	29.55	33.04	3.16	9.5
16	229	58	34.86	37.20	2.34	6.3
17	229	70	39.85	43.04	3.19	7.4
18	230	85	45.00	47.79	2.75	5.8
19	230	90	50.00	52.60	2.60	4.9
20	230	85	55.00	57.54	2.54	4.4

This engine was 8 inches in diameter of cylinder, 14 inches stroke of piston, having a rod 44 inches long be-

not hold, and that it is as nearly correct to say that the friction of engine is constant as otherwise. The column of friction, as given in percentages of the total power, exhibits the same fact. There is continual, though somewhat irregular, reduction of the percentage of friction, throughout the range from the lowest to the highest power, and very nearly inversely as the power exerted. This is best shown by the curve given in the accompanying plate (Fig. 23), in which a smooth line has been drawn to represent as nearly as possible the mean of all observations. It is evidently more nearly correct to assert that the friction of a non-condensing engine of this class is constant, and independent of the total power developed, than to accept the rule of De Pambour. The power for which the engine is proportioned is 35 to 40 horse-power. At this power, the friction of engine is but about 6 per cent. of the total, or less than one-half that assumed by De Pambour, and accepted as correct by Rankine, for engines generally, and presumably for locomotives especially. The result is exceedingly gratifying, and seems to the writer extraordinary for so small an engine.

The repetition of the experiment upon an engine of another make, having a cylinder 9 inches in diameter and a stroke of piston of 12 inches, which would naturally give

a somewhat increased percentage of friction, in consequence of the proportionally smaller stroke, at 20, 30, 50 and 65 horse-power, by brake, and running free, revolutions 300 per minute—a speed which may also have caused some increase in frictional resistance, not only in rubbing parts, but by increasing back pressure—gave a friction of engine measuring from 2.66 horse-power unloaded, to 4 horse-power at 20 to 30 horse-power, 4.8 horse-power at 50, and 5.3 at 65 horse-power, the total friction increasing perceptibly, as assumed by De Pambour, but decreasing in percentage of load, from 16 to 7.5, between 20 and 65 horse-power. It is very nearly constant throughout the whole range of power that the engine would be worked under ordinary circumstances, and may be so taken without serious error; while the adoption of the De Pambour formula would give a value of f so small that its use would not be attended, ordinarily, with sufficient increased exactness to compensate for the additional trouble in-

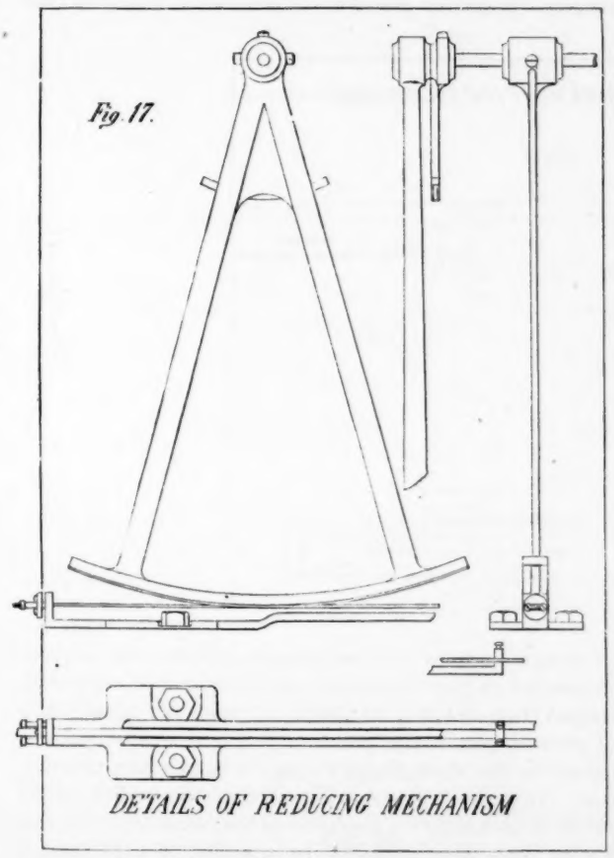


Fig. 17.

DETAILS OF REDUCING MECHANISM

volved in its application. At their rated powers the two engines thus exhibit efficiencies of mechanism of about 94 and 90 per cent., respectively.

The second series of experiments were made * during the latter part of last college year, confirming the deductions already given, while some very interesting and original modifications were made in the details of method and trial. The engine taken for test was a machine recently built and sent to the Cornell University for purposes of experimental investigation in electrical measurement and other work of the college. It is an engine 7 inches in diameter of cylinder and 12 inches stroke, or more exactly, 6⅞ inches in diameter; the cylinder having been bored slightly under size. The general plan of the engine is similar to the first of those already described, and, like that, is carefully designed with a view to reducing friction to a minimum, and giving a regulation of maximum efficiency. The brake was precisely like that used in the first described experiments, and was built for the engine constructed in the college workshops, under the direction of the inventor, and exhibited at the Centennial Exhibition in 1876. It was constructed by the Straight Line Engine Company and adapted, with very little alteration, to the new engine. The indicators were carefully standardized and put in good order in every respect, by the makers, for the purposes of these investigations. The reducing mechanism used in connecting the indicator barrel to the cross-head of the engine was designed and built by the observers, and fitted with a very firm connecting arrangement, and with an ingenious detaching device. A sector was constructed which was pivoted above the cross-head, and hung in the vertical plane above the latter, the engine being horizontal. The arc of the sector carried a pair of steel ribbons, one attached to each end, each carried around the arc and secured, at its opposite end, to the end of a bar fastened on the cross-head, in such manner that the two ends of the ribbons at the cross-head bar being well secured and tightly drawn up, by means of screws placed conveniently for the purpose, all back-lash was prevented, and an absolutely exact synchronism of movement of indicator line and cross-head was obtained. The engine was driven at 285 revolutions per minute, and it was, therefore, very important that this rigidity of connection should be secured. A smaller sector at the upper part of the larger one was the carrier of the cord, and the combination was thus a perfect means of reproducing the motion of the engine on the smaller scale required in working the paper-barrel of the indicator. The "cord" was piano wire, a material much less liable to cause difficulty by stretching than any other that was available. Its free part was kept taut by a "spiral" (helical) spring, attached beyond the point of connection with the paper cylinder.

In the first of these experiments, as already described, Thompson indicators were used; in those about to be considered, Crosby instruments. It was hoped that the new Tabor indicator could be used also, but none were received in time. The instruments used worked perfectly, and gave no trouble from beginning to end. The speed indicators were of several kinds. Hand instruments of two or three kinds were used to check the records of the automatic instruments. A "tachometer" was attached and belted to the engine-shaft, and afforded a very convenient means of watching the momentary fluctuations due to variations of load, of steam pressure, and of accidental disturbances. A chronograph was also attached, connected with the standard clock in the physical laboratory, to beat seconds. A commutator was placed on the engine-shaft, making contact at each revolution, and a key near the engine, for the purpose of breaking contact. A Brown mercury speed-indicator served excellently well for a constant speed-indicator. It exhibited instantly any variation of speed from the normal. The chronograph was set in operation when the indicator cards were taken, and thus gave the exact speed of the engine at that instant. Great care was taken to keep the instruments, and the engine as well, in good order and well lubricated throughout the series of experiments. Some stiffness of the governor, however, the cause of which was not dis-

* By Messrs. W. A. Day and W. H. Riley, at Cornell University.

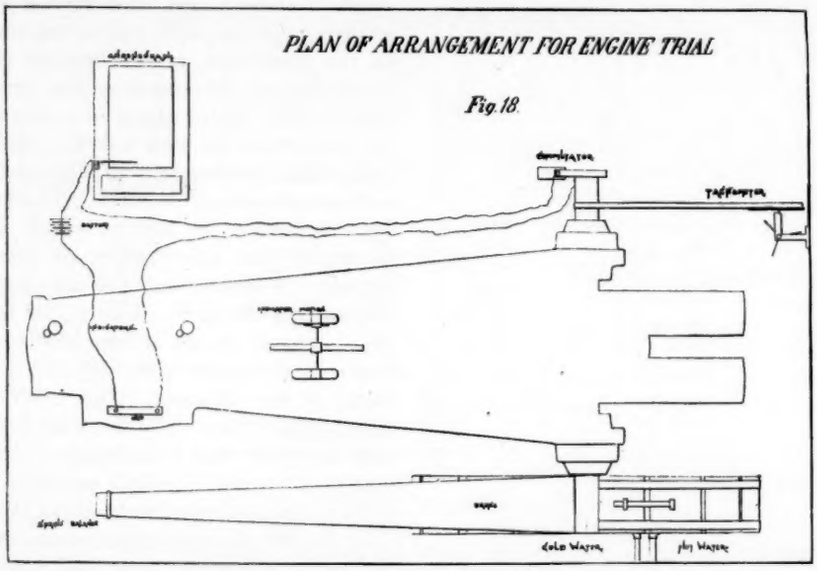
covered until after the work had been completed, caused it to work less perfectly than in the engine first used, and the speed varied more than in that series of determinations. When the governor was in its most perfect adjustment, the engine was capable of holding the standard speed within a fraction of one revolution throughout a wide range of work, and nearly down to the lowest power that such an engine is at all likely ever to be called upon to supply.

The mean effective pressure required to drive the engine alone, loaded and unloaded, throughout the whole range of the trials here made, was 4.55 pounds per inch of piston, and was nearly constant, as in the first investigation. The steam pressure usually ranged between 65 and 75 pounds per square inch at the steam-chest, but, when it was desired to secure a card to be more easily worked up, the pressure was dropped to 20 pounds. A series of special experiments made to determine the question whether the friction of engine is variable with boiler-pressure, although not in all respects satisfactory, indicated a slight increase in engine friction as steam pressures rose. The conclusion already arrived at by the writer, as deduced from the work previously done, that the engine friction, in this class of steam-engine, is constant, or sensibly so, under all loads, is thus here again confirmed. The following are the data obtained, arranged as before, to exhibit the relation of the indicated to the dynamometric powers:

1. No. of Card.	2. Rev. per Minute.	3. Steam Press.	4. Brake Power. H. P.	5. Ind. H. PPI. per card.	6. Diff. Frict. H. P.	7. Mean F. Press.	8. Friction per cent.
1	282	19	0	2.26	2.26	3.70	100
2	288	65	4.87	8.43	3.56	5.56	42
3	286	66	7.61	10.95	3.33	5.25	30
4	284	65	10.30	12.93	2.89	4.13	20
5	285	71	13.10	15.99	2.61	4.25	18
6	284	76	15.80	18.79	2.99	4.71	16
7	284	74	18.55	20.73	2.65	4.18	12
8	280	67	21.00	23.73	2.73	4.37	11
9	279	65	23.61	25.95	2.33	3.73	9
10	280	75	26.39	29.95	2.36	5.38	11
11	280	72	29.03	32.22	3.19	5.15	10

The first glance at column 6 or at column 7 of the above table, in which the horse-power absorbed by the friction of the engine, and the mean effective pressure corresponding to that power are presented, shows that, as already concluded, the resistance of this class of engine at constant speed, is practically constant at all loads and that the differences and irregularities observed are due to accidental causes. The variation of speed recorded here is in some cases due to differences of steam pressure, partly purposely produced, and partly coming of the fact that it was necessary to take steam as it could be obtained, and was impracticable to secure steady pressure, and in other instances was due to the fact, afterward discovered, that the governor had been adjusted in such manner as to be slightly cramped, and thus deprived of its wonderful sensitiveness and accuracy, as exhibited before this defect had been introduced, and after it had been remedied. Chronograph records, made later by Prof. Anthony, exhibit the most extraordinary smoothness.

These variations of speed served the useful purpose of calling attention to the fact that the engine-friction varied, at constant load and speed, with variation of steam pressure, and to a very noticeable amount, within the usual range of pressures met with in practice. It is seen that



in rising from 19 to 76 pounds steam pressure, the pressure demanded to give the engine its normal speed, unloaded, ranged from below 4 to above 5 pounds per square inch of area of piston, the pressure required in the cylinder rising, on the whole, though irregularly, as steam pressure rose. In order to determine whether this, which might prove to be a hitherto unobserved law, were true, the following data were obtained by a series of experiments made for the purpose of settling this new question:

No. of Card.	Rev.	Steam Press.	I.H.P.	Mean Press.	Mean F. Press.	Per ct. Frict.	
1	250	25	6.01	10.84	1.95	18	Ten pounds on the brake.
2	271	39	6.52	10.85	2.71	27	
3	285	42	7.17	11.35	3.63	32	
4	280	46	7.08	11.60	3.59	31	
5	271	58	6.81	11.28	3.16	28	
6	289	63	7.85	12.25	4.65	38	
7	286	68	7.77	12.25	4.90	40	
8	283	77	7.88	12.47	3.74	38	
9	296	82	7.87	12.00	4.68	39	
10	275	71	2.10	3.46	3.46	100	No load on the brakes.
11	279	66½	1.995	3.22	3.22	"	
12	277	44	1.708	2.78	2.78	"	
13	275	35	1.71	2.80	2.80	"	
14	275	30	1.613	2.64	2.64	"	
15	272	25	1.876	3.11	3.11	"	
16	270	19	1.724	2.88	2.88	"	
17	270	15	1.712	2.86	2.86	"	

In the first set of experiments, here numbered 1 to 9, inclusive, the weight on the brake-arm was kept constant at ten pounds; in the remaining experiments all weight was removed. In both sets, the same general effect is seen. As the steam pressure rises, the speed being the same and the resistance the same, the friction of the engine increases; from 2 pounds, at 25 pounds pressure in the steam-chest, to nearly 5 pounds per square inch of piston at the maximum, 82 pounds steam in the valve-chest. As the steam pressure fell from this point to 15 pounds, in experiments 9 to 17, the load being thrown off entirely, and the speed being nearly constant, the mean pressure measuring the friction of engine falls again below 3 pounds per square inch of piston. The difference is considerably less in the last series than in the first; which

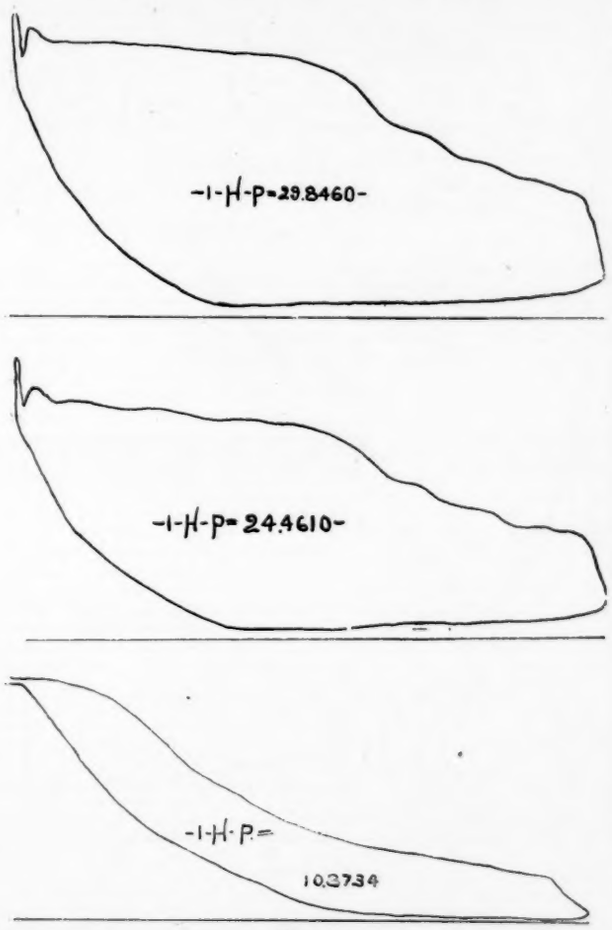


Fig. 19.

apparent discrepancy is accounted for by the fact that the variation of steam pressure in the first series was accompanied by a greater change of speed of engine than in the second. The resistance is seen to increase slowly, therefore, with increase in speed of rotation. The effect of change of pressure is, in these cases, more marked than that of alteration of velocity of the engine.

The accompanying illustrations show the apparatus and exhibit the facts revealed by the investigations, which have now been described, better than can the text. Fig. 15 shows the method of attaching the indicators, with an elevation of the engine cylinder and section at the cross-head; Fig. 16 exhibits the same arrangement in plan; Fig. 17 gives an enlarged view of the reducing mechanism and attachment to the cross-head; Fig. 18 is an outline plan of engine and surroundings, exhibiting the location of instruments; and Figs. 19 and 20 represent characteristic diagrams obtained by means of the indicator, showing the variations of steam distribution with variations of load on the brake. All these illustrations refer to the work of later date. Figs. 21 and 22 are given to exhibit the method of variation of mean friction pressures with variation of load, the variation of the percentage of friction resistance as a fraction of total resistance with vary-

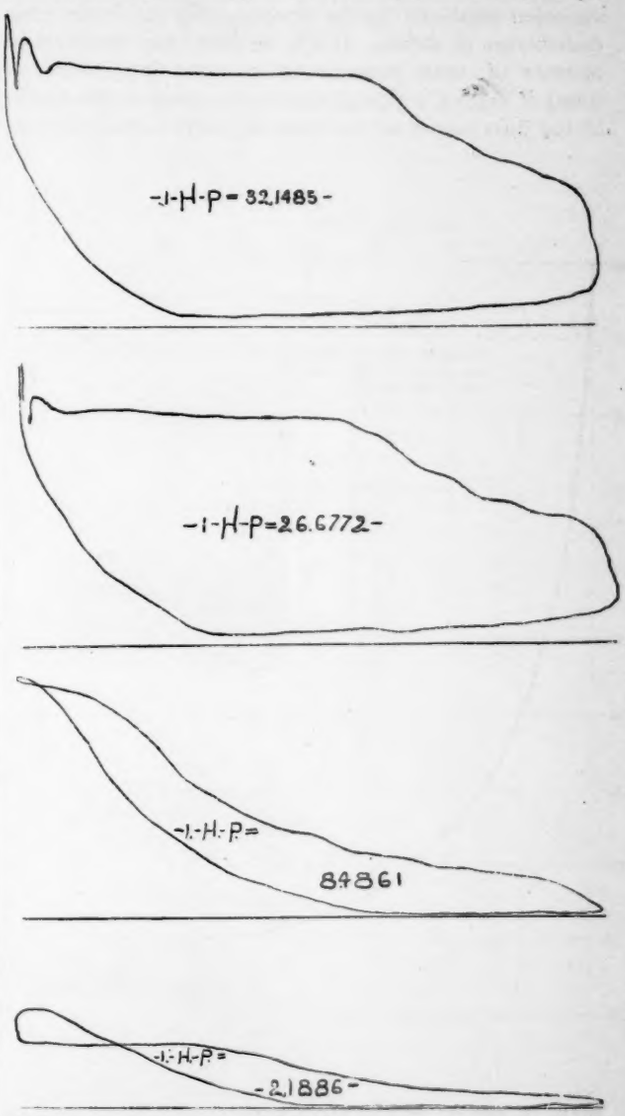


Fig. 20.

ing loads, for the last investigation; and, for comparison the same ratios, as obtained in the work done at the American Institute Exhibition, are given in Fig. 23. These last curves are seen to be approximately hyperbolic; while the first given is a straight line. The originals of these curves were carefully plotted by Messrs. Day and Riley, from the records of original observations, and beautifully represent the laws which it was the object of these investigations to reveal and establish.

After a survey of this work, it may be asked, How does it happen that rise in steam pressure produces evident increase of the frictional resistance of the engine? It was long ago shown by the writer, and is now well established by many independent investigations, that, with good lubrication, increase of pressure on a journal gives de-

creased co-efficients of friction, and this would seem to show that the friction of engines in which the resistance caused by friction is mainly due to journals and lubricated surfaces, should become less as pressures increase, the useful load and the speed of engine remaining constant. This query is a very natural one, and is based upon a correct statement of fact, however inconsistent it may seem to be with the results above derived. The cause of the apparent discrepancy is attributable, probably, to the variation produced by the action of the governor in the distribution of steam. It will be seen that the effect of increase of steam pressure is to cause acceleration of speed of engine, a change essential to produce the action of the governor at all, and that it results in the readjustment of the set of the valve in such manner as to cause the greater proportion of the nearly constant amount of work performed to be done more nearly at the commencement of the stroke, at a point in the orbit of the crank-pin at which the work is mainly lost by friction, and to reduce the proportion of total work done at or near the "half-center," where it is principally useful. The proportion of useful to lost work is thus varied in such manner as to give a mean final result which is the less favorable as the steam pressure is higher, and the cut-off shorter, giving a higher ratio of expansion. It is also evident that, if this explanation is correct, the difference here noted will be less as the point of cut-off approaches and passes the half-stroke position of piston and cross-head. Could the valve be set with negative lead for all positions at the point of cut-off, as is considered right by some experienced engineers, the work would be more nearly performed at positions removed from the "dead points," and the variation here described would be thus reduced, while the efficiency of the engine would be increased.

Prof. Rankine proposed the formula:

$$R = R_1 (1 - f) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2.)$$

This formula is evidently inadmissible, at least for the class of engine which was made the subject of the experiments which have been here described. Since the friction of engine is, so far as can be here seen, sensibly independent of the magnitude of the load and of the resistance produced by it, the correct formula would seem to be:

$$R = R_1 + R_0 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3.)$$

the total resistance met at the piston being the sum of the resistance of the engine itself and that of the load, both being determinable, both being independent, and being governed by entirely different laws.

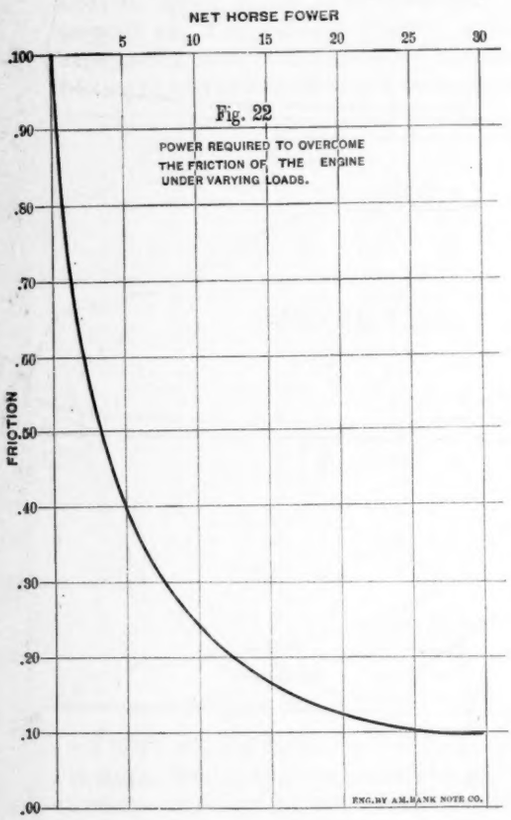


Fig. 22

POWER REQUIRED TO OVERCOME THE FRICTION OF THE ENGINE UNDER VARYING LOADS.

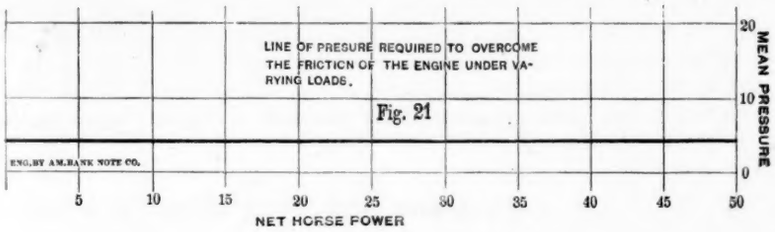


Fig. 21

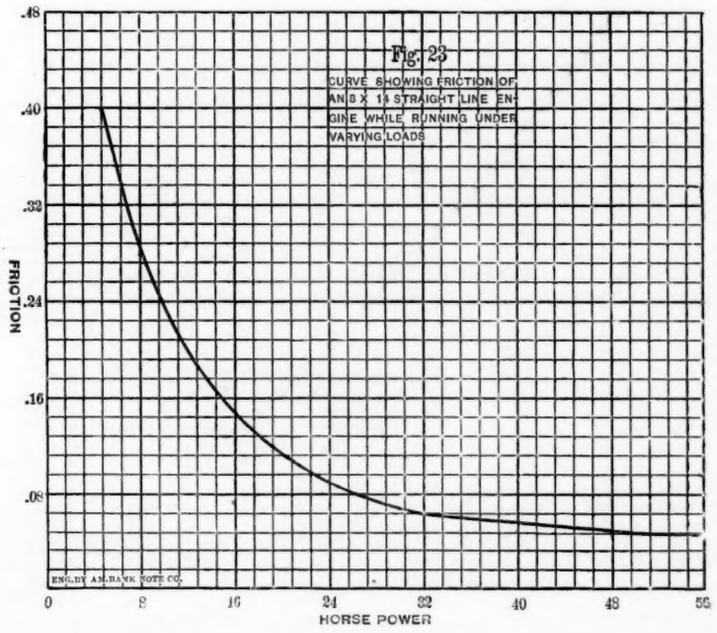


Fig. 23

CURVE SHOWING FRICTION OF AN 8 X 14 STRAIGHT LINE ENGINE WHILE RUNNING UNDER VARYING LOADS

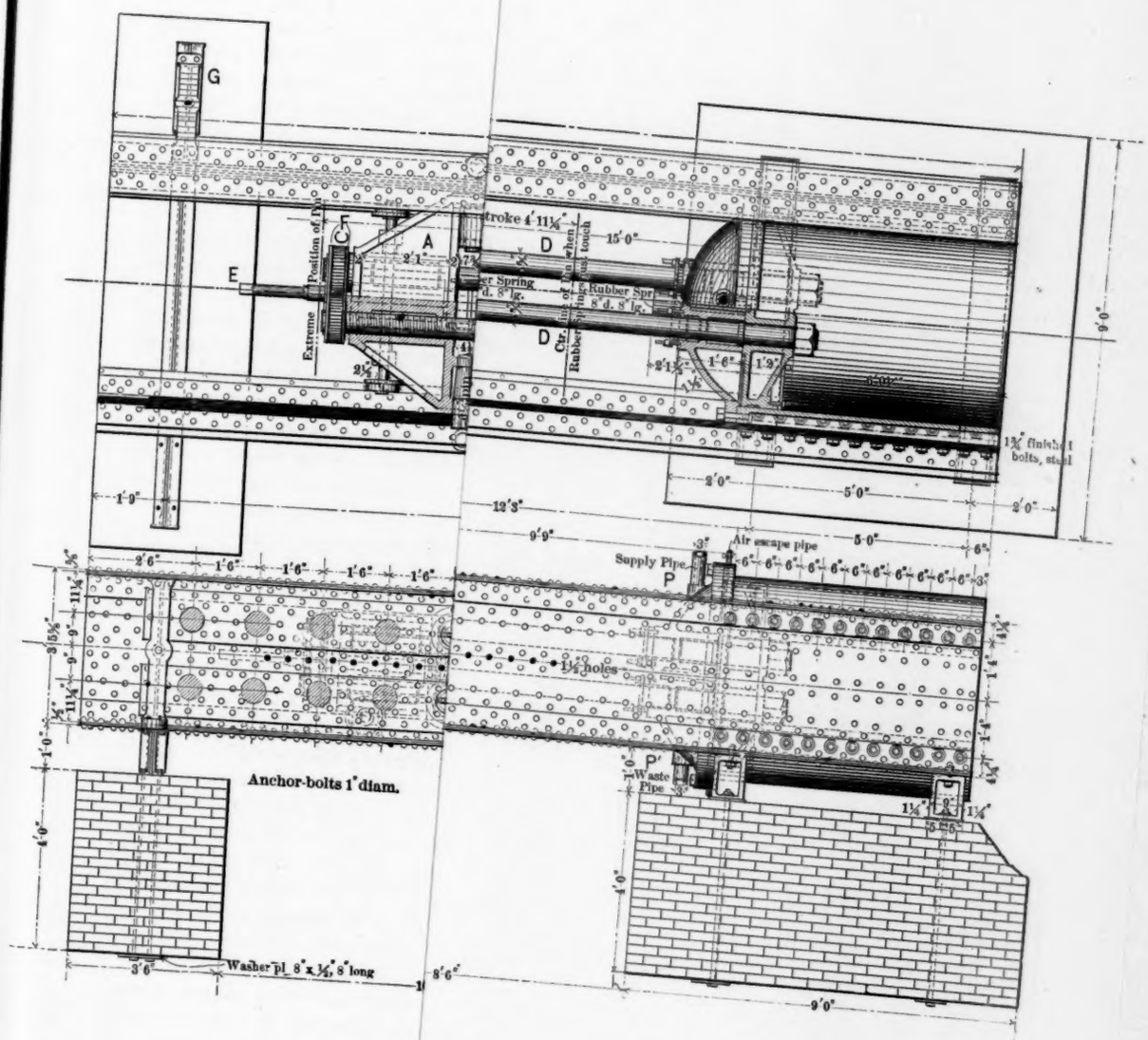
The conclusions to be drawn from what has preceded are obviously the following:

(1.) The friction of the non-condensing engine, of the class here described, is sensibly constant at any given speed, at all loads, and is, at different speeds, entirely independent of the magnitude of the load.

(2.) The friction of engines, of the type described, is variable with variation of speed of engine, increasing as speed increases, in some ratio as yet undetermined, but probably different with every engine, and, for the same engine, with every change of conditions of operation.

(3.) The friction of engines increases with increase of steam pressure, in the case of the class here referred to, in a probably similarly variable manner with that observed

Plate I.


G
F
C
A
E
D
D
15'0"
2'1"
Position of Dog when stroke 4'11¼"
Extreme
Ctr. of Rubber Ring when touch
Rubber Spring
d. 8"lg.
2¼"
1'6"
1'3"
6'0½"
1¼" finish'd bolts, steel
9'0"
1'9"
2'0"
5'0"
2'0"
12'3"
9'9"
3"
Air escape pipe
5'0"
6"
2'6"
1'6"
Supply Pipe
P
1¼ holes
Anchor-bolts 1" diam.
P'
Waste Pipe
3"
1¼"
1'0"
3'6"
Washer pl. 8"x¼", 8" long
8'6"
9'0"

creased co-efficients of friction, and this would seem to show that the friction of engines in which the resistance caused by friction is mainly due to journals and lubricated surfaces, should become less as pressures increase, the useful load and the speed of engine remaining constant. This query is a very natural one, and is based upon a correct statement of fact, however inconsistent it may seem to be with the results above derived. The cause of the apparent discrepancy is attributable, probably, to the variation produced by the action of the governor in the distribution of steam. It will be seen that the effect of increase of steam pressure is to cause acceleration of speed of engine, a change essential to produce the action of the governor at all, and that it results in the readjustment of the set of the valve in such manner as to cause the greater proportion of the nearly constant amount of work performed to be done more nearly at the commencement of the stroke, at a point in the orbit of the crank-pin at which the work is mainly lost by friction, and to reduce the proportion of total work done at or near the "half-center," where it is principally useful. The proportion of useful to lost work is thus varied in such manner as to give a mean final result which is the less favorable as the steam pressure is higher, and the cut-off shorter, giving a higher ratio of expansion. It is also evident that, if this explanation is correct, the difference here noted will be less as the point of cut-off approaches and passes the half-stroke position of piston and cross-head. Could the valve be set with negative lead for all positions at the point of cut-off, as is considered right by some experienced engineers, the work would be more nearly performed at positions removed from the "dead points," and the variation here described would be thus reduced, while the efficiency of the engine would be increased.

Prof. Rankine proposed the formula:

$$R = R_1 (1 - f) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2.)$$

This formula is evidently inadmissible, at least for the class of engine which was made the subject of the experiments which have been here described. Since the friction of engine is, so far as can be here seen, sensibly independent of the magnitude of the load and of the resistance produced by it, the correct formula would seem to be:

$$R = R_1 + R_0 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3.)$$

the total resistance met at the piston being the sum of the resistance of the engine itself and that of the load, both being determinable, both being independent, and being governed by entirely different laws.

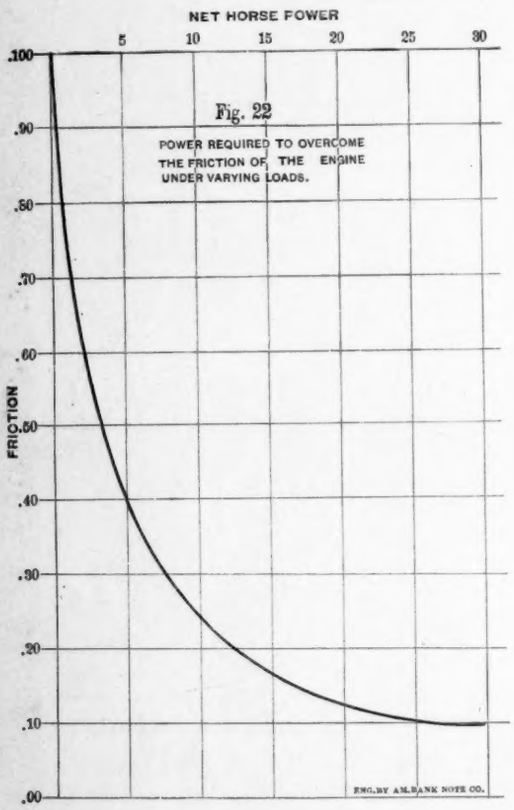


Fig. 22

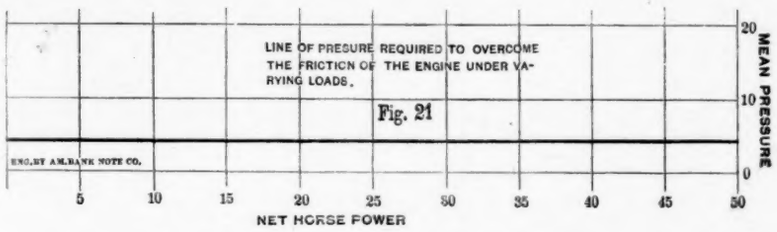


Fig. 21

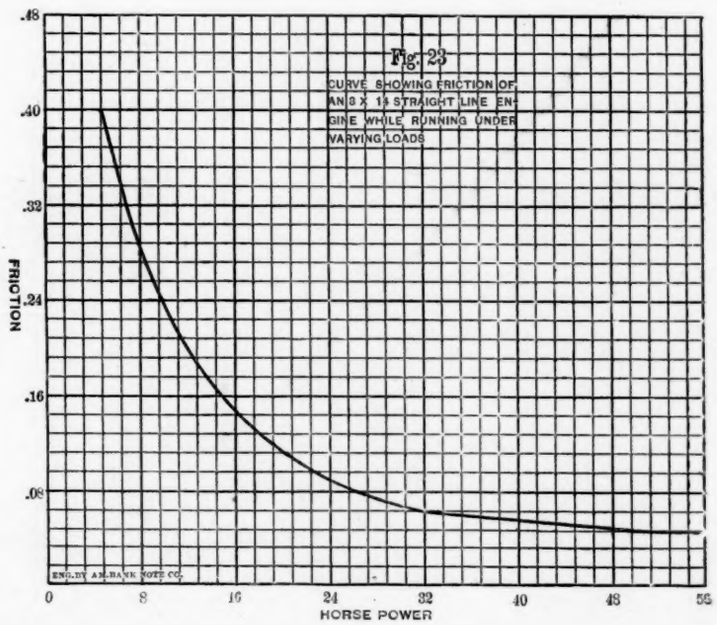


Fig. 23

The conclusions to be drawn from what has preceded are obviously the following:

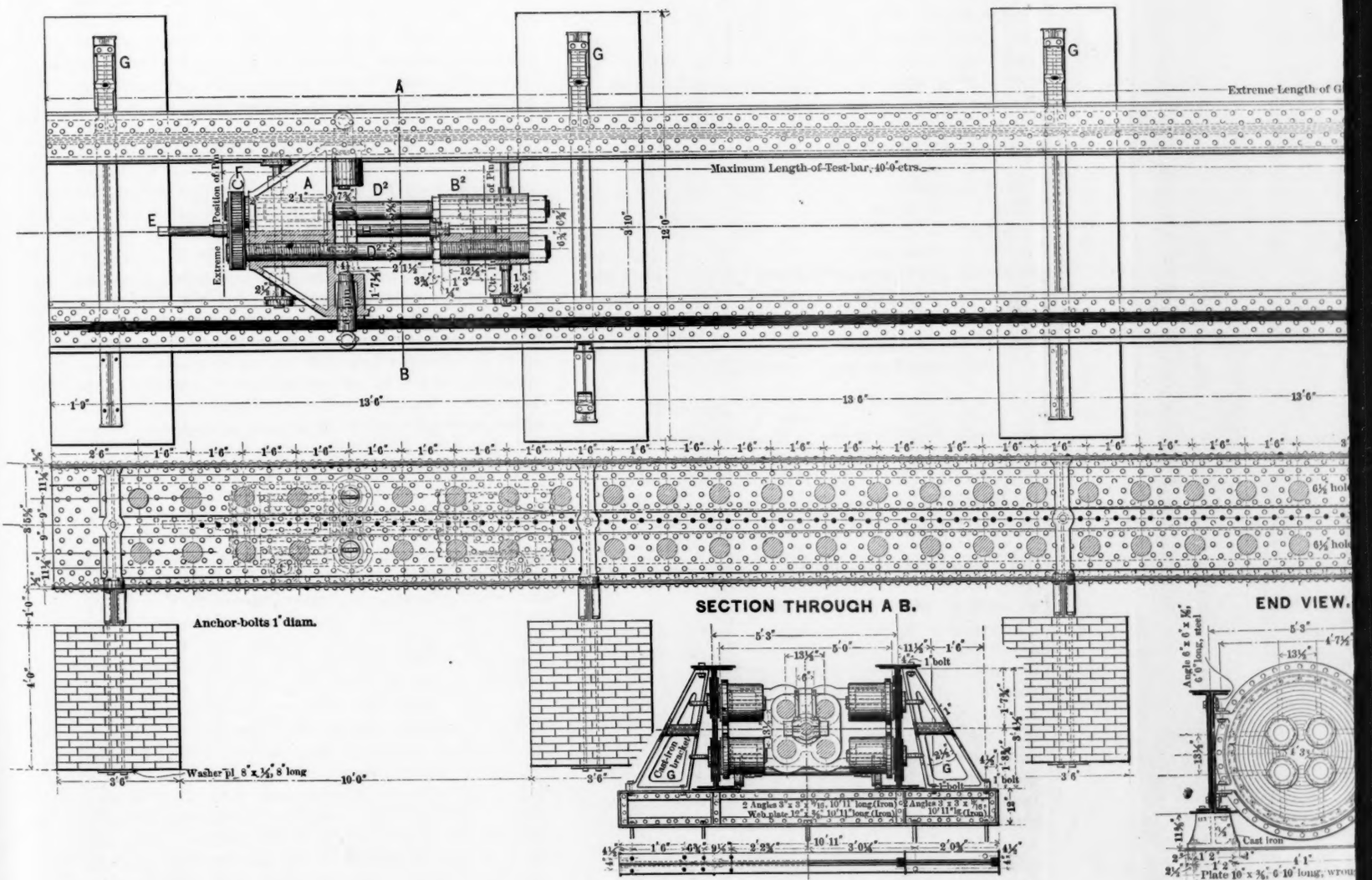
(1.) The friction of the non-condensing engine, of the class here described, is sensibly constant at any given speed, at all loads, and is, at different speeds, entirely independent of the magnitude of the load.

(2.) The friction of engines, of the type described, is variable with variation of speed of engine, increasing as speed increases, in some ratio as yet undetermined, but probably different with every engine, and, for the same engine, with every change of conditions of operation.

(3.) The friction of engines increases with increase of steam pressure, in the case of the class here referred to, in a probably similarly variable manner with that observed

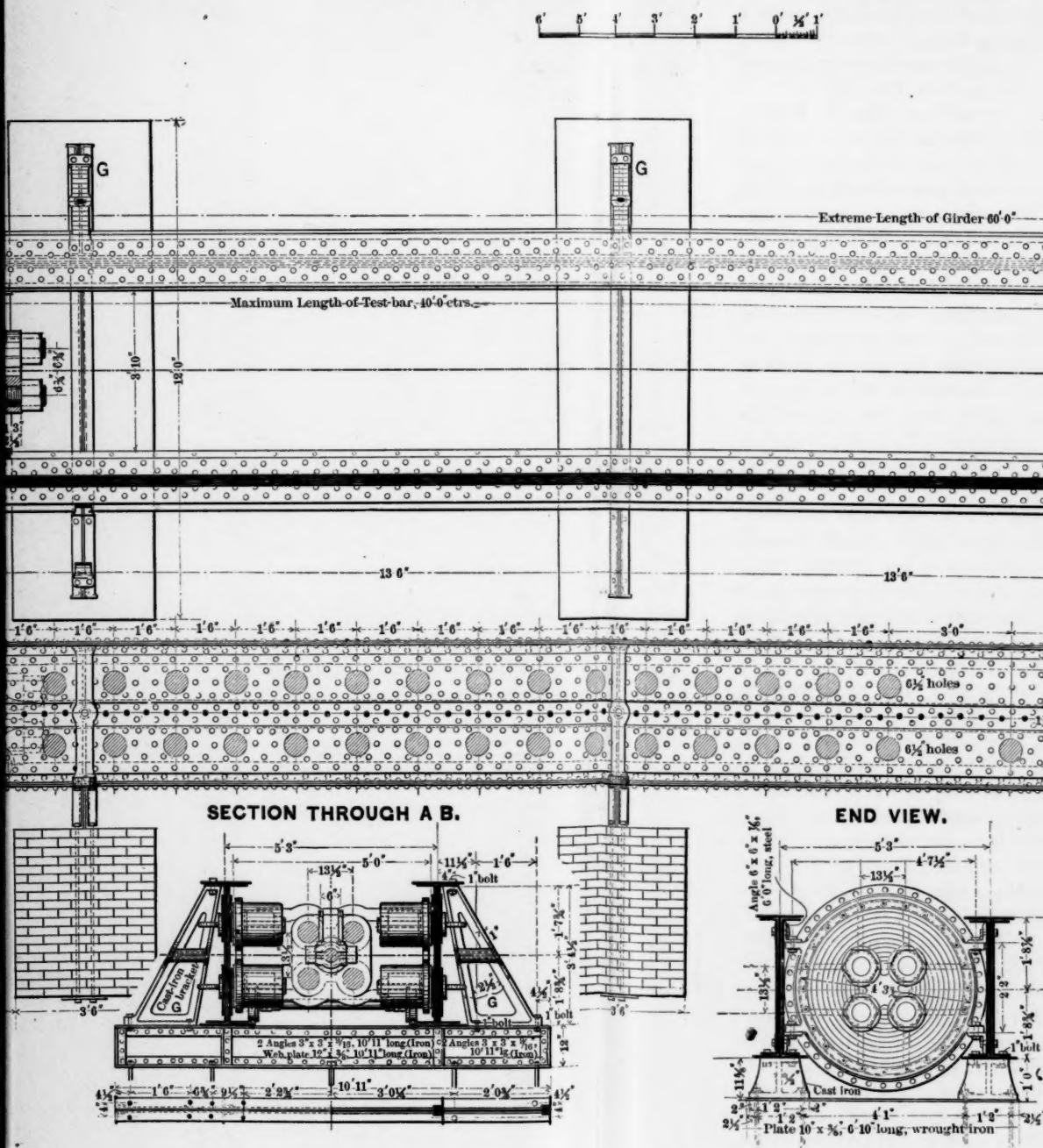
GENERAL PLAN OF 1,200,000 LBS. TEST

MAXIMUM WATER-PRESSURE 600 LBS. PER SQUARE I



GENERAL PLAN OF 1,200,000 LBS. TESTING

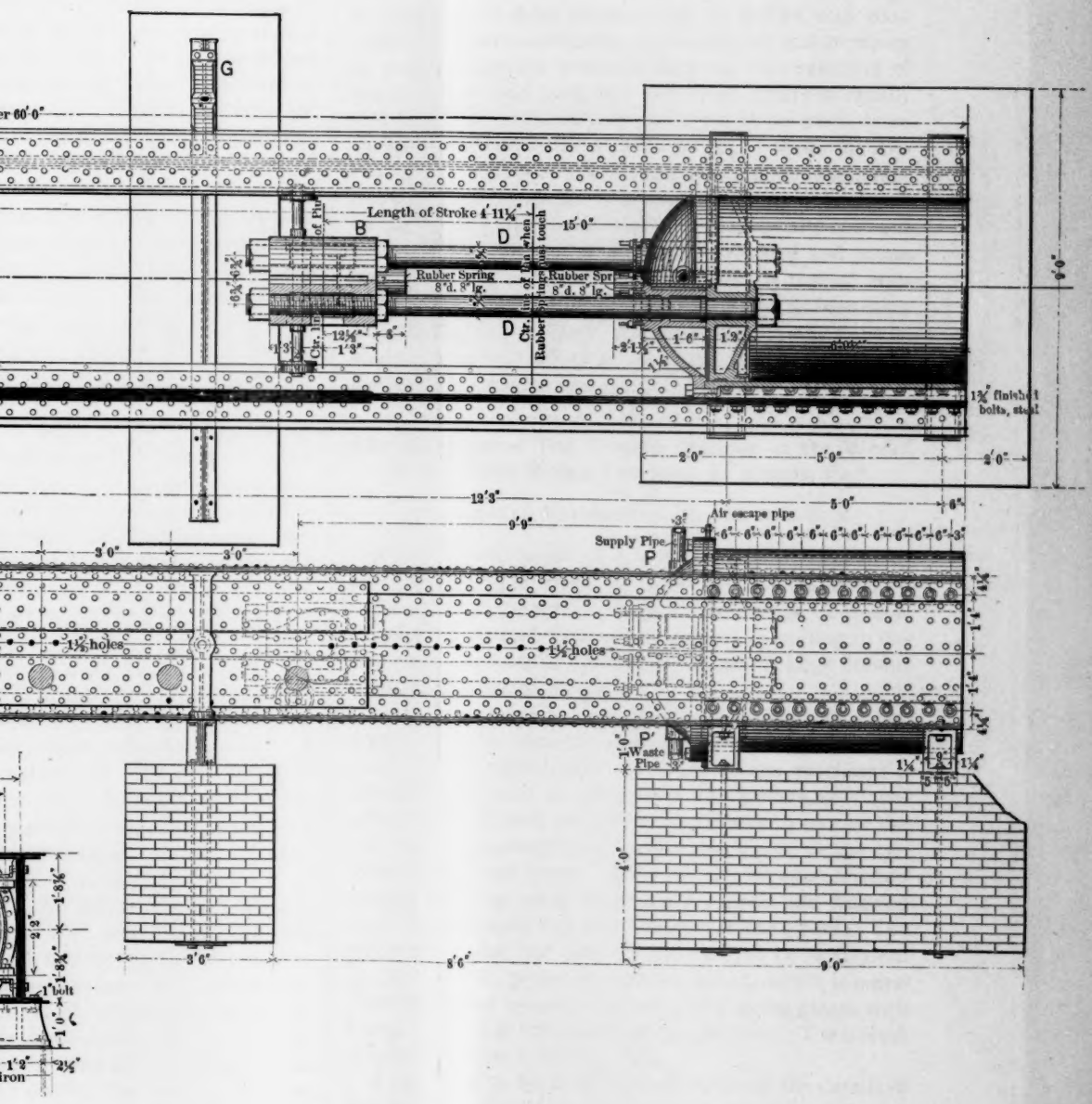
MAXIMUM WATER-PRESSURE 600 LBS. PER SQUARE INCH.



NG MACHINE.

CH.

Plate I.



with alteration of speed, neither method of variation being capable of representation by any convenient algebraic expression.

(4.) The total resistance measured at the piston of the engine is composed of two parts, the one sensibly constant at the working speed, the other variable with external load, and may be, for practical purposes, at least, represented by the expression:

$$R = R_1 - R_0,$$

in which R is the total resistance, as shown on the indicator diagram R_1, the resistance due to the external load; *e. g.*, as measured by a Prony brake, and R_0 the resistance of the unloaded engine, as shown by a "friction card" taken with the steam-engine indicator.

It is sufficiently obvious that these conclusions are, at present at least, only certainly applicable to one class of engine. It is not improbable that the condensing engine may be subject to quite different laws. It is to be hoped that this question may be settled by direct experiment at an early day. The custom has obtained, hitherto, of allowing a certain pressure per square inch of piston as the equivalent of the friction resistance of the engine in marine practice—this pressure being taken at from 2½ pounds in the case of engines of moderate size, to 1½ with the largest engines. It has never yet been ascertained whether, or to what extent, the friction of engine is augmented by the imposition of load. The assumed figure represents from 5 to 10 per cent., usually, of the total indicated power of the engine. Isherwood has taken 7½ per cent. of the useful load as the amount of increase of friction of engine due to its action. This estimate is stated to be made on the basis of the data given by General Morin, whose co-efficients for friction of lubricated surfaces are now known to be enormously larger than those customarily met with in practice in well lubricated journals of large size working under heavy pressures. In such cases, when the surfaces are in good order, the co-efficient is known to fall to below 1 per cent., instead of being from 3 to 5, as given by Morin, as determined under the different conditions of his experiments. Where the journals are not well lubricated, and especially when they are rough or cut by abrasion, friction may increase enormously and may pass far beyond the figures given by Morin even; but such exceptional conditions cannot be taken into account to establish laws for application in design, or in good practice. For all cases in which the friction varies, as in the examples here above illustrated, the "friction card" sensibly represents the correct tare, whether the engine be loaded or unloaded.

A word in explanation of the fact here shown that the increased load thrown upon the shaft, crank-pin, and cross-head journals does not noticeably increase the friction of engine, will be considered not out of place here. The friction of engine consists of the resistances due to the motion of the various piston, valve, and other rods through stuffing-boxes and in guides, the friction of the piston rings on the cylinder surface, the friction of eccentrics, and, often, other parts which are independent of the magnitude of the load thrown upon the engine by the useful resistance, in addition to the friction of the journals transmitting the effort of the steam to the exterior resisting work, and of the cross-head guides and other parts indirectly affected by its variation. It thus happens that the resistance due to the friction of the latter may be, and often is, but a small proportion of the whole friction of engine. The total friction of engine, as has been seen, in engines of the class here studied, and of the sizes described, amounts to about 10 per cent. of the total power developed when fully loaded; but the co-efficient of friction of any one journal, if well lubricated, has been found by the writer, by hundreds of experiments, under such pressures as are usual on the main journals of the steam engine, to fall below 1 per cent., and the absorption of work and energy is thus a still lower proportion of the work of the steam in proportion as the speed of rubbing is less than that of the piston. The loss of power along the line of connection is thus exceedingly small. It should never exceed probably 2 per cent. of the work done, or between 10 and 20 per cent. of the total friction. Again, the co-efficient of friction, within the usual range of pressures on these journals and the guides, with good lubrication, increases rapidly as pressures fall, and decreases as greatly when the pressures increase with variation of engine power and load, and this often occurs so rapidly that the total frictional resistance, on these parts, even, varies very slowly with variation of load; while the friction of the other portions of the engine, above mentioned, remains quite constant. The resultant effect is, as shown by the investigation here described, a practically constant friction of engine under all loads, the speed and steam pressure being constant. Whether this is true of condensing engines is doubtful, and it would be an important extension of this research, could similar investigations be made of the friction of other forms, and especially the marine steam-engine and pumping engines.

The Six-Hundred Ton Testing Machine at the Works of the Union Bridge Company, at Athens, Pa.*

BY CHARLES MACDONALD, M. AM. SOC. C. E.

A BRIEF description of a testing machine capable of exerting a tensile strain of 1,200,000 pounds, recently constructed at the works of the Union Bridge Company, at Athens, Pa., and successfully applied in pulling to destruction a number of eye-bars of unusually large dimensions, may prove of interest.

In general it may be described as consisting of a hydraulic cylinder securely fastened between two longitudinal girders, which form the frame of the machine; a tail block attached to the webs of the girders at convenient intervals, and two connecting blocks to receive the test pieces, attached respectively to the piston of the cylinder and the tail block. They are carried upon finished wheels, running upon an accurately lined and finished track resting upon the lower flanges of the girders. The strain upon the test piece is assumed to be equivalent to the hydraulic pressure upon the piston, which is measured by a Shaw mercury column and a spring gauge, both being referred to the center of the cylinder. The stretch is recorded upon a natural scale.

A reference to the drawings will indicate the details of this simple piece of mechanism, and, it is hoped, furnish evidence of the accuracy of the methods by which important results have been obtained.

Inasmuch as the arrangements for applying compression strains have not yet been perfected, although they are in

* Paper read at the Annual Meeting of the American Society of Civil Engineers.

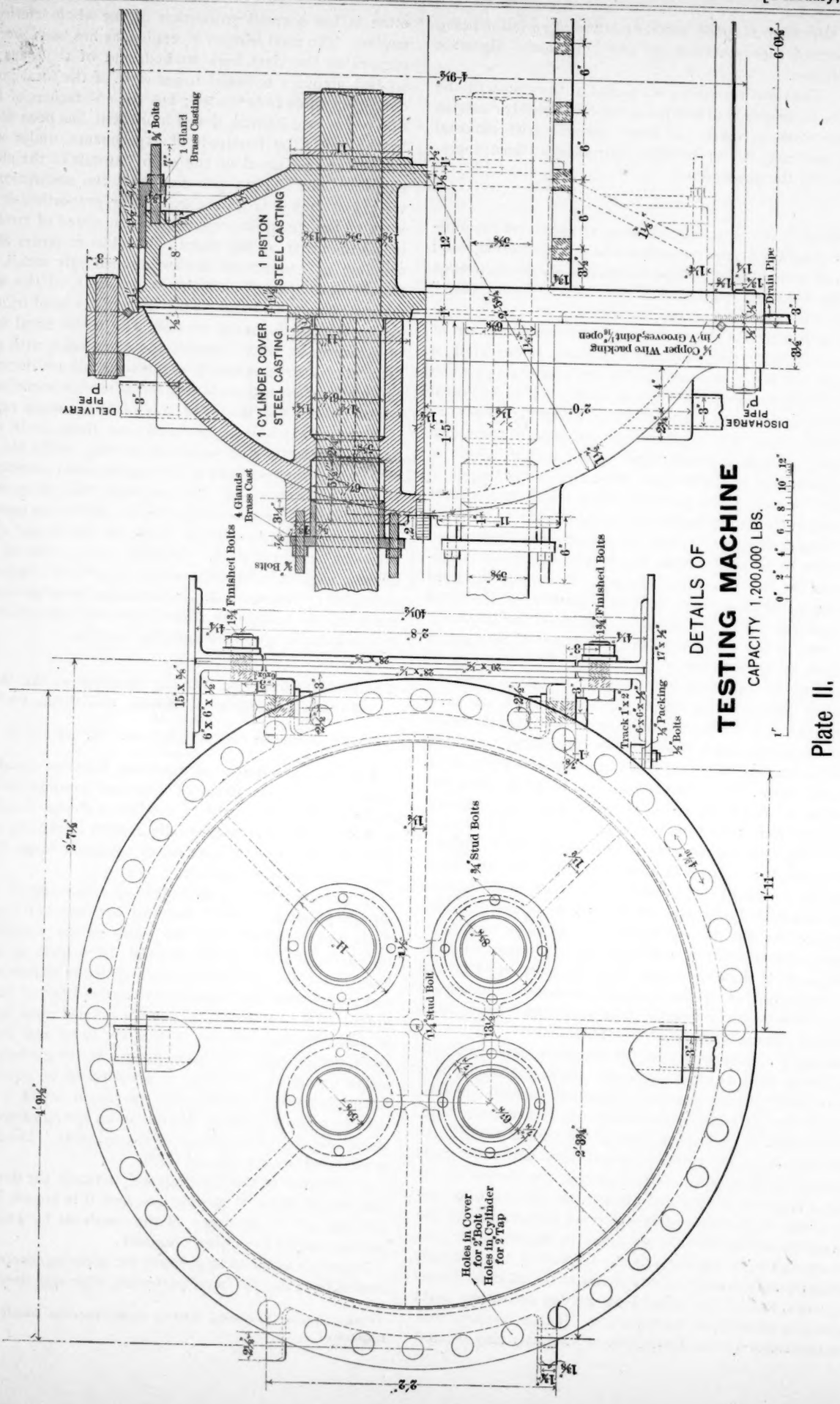

DETAILS OF
TESTING MACHINE
CAPACITY 1,200,000 LBS.
1 PISTON STEEL CASTING
1 CYLINDER COVER STEEL CASTING
1 Gland Brass Casting
¾" Bolts
4 Glands Brass Cast
¾" Bolts
Finished Bolts
Finished Bolts
¾ Copper Wire packing in V Grooves, Joint 1/16 open
Drain Pipe
DELIVERY PIPE
DISCHARGE PIPE
Track 1" x 2"
¾ Packing
½" Bolts
¾" Stud Bolts
1¼" Stud Bolt
Holes in Cover for 2" Bolt,
Holes in Cylinder for 2" Tap

Plate II.

a forward state of preparation, your attention is directed to the machine as at present adapted to tensile strains only, reserving to the near future a presentation of the completed machine.

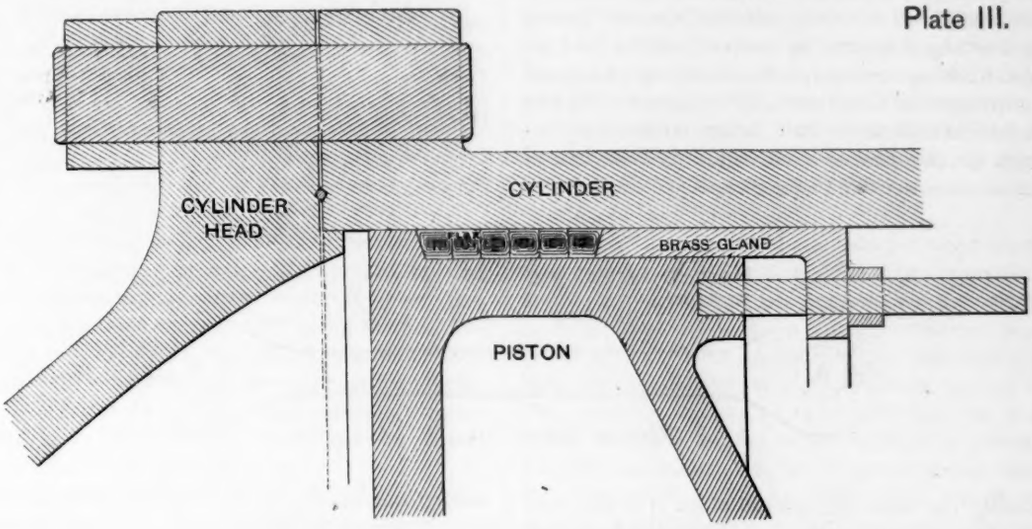
Plate I represents a general plan and elevation with sections. The cylinder is of cast-steel, 4 feet 3¾ inches diameter and 6 feet 0½ inch long, giving an effective area of 2,039 square inches, and a working stroke of 4 feet 11 inches. The maximum water pressure for which provision has been made is 600 pounds per square inch, which, for a piston area of 2,039 inches, produces a total strain upon the test piece of 1,223,400 pounds, under the assumption, which is believed permissible, that the resistance due to friction is sufficiently small to be neglected. For the purpose of facilitating observations, it is intended that the cylinder should have an effective area of exactly 2,000 square inches, so that one pound upon the gauges would indicate a ton of pressure, but a defect in the casting made a slight increase in the bore necessary. It is secured to the girders by steel bolts and angles, and the outer end is left open for inspection. The piston and rods are packed with ordinary packing, to be more fully described hereafter. The main girders are of wrought-iron, 60 feet long by 3 feet 5⅜ inches high, built up of plates and angles rolled in one length. Holes are bored through the webs, 6½ inches diameter and 18 inches apart, for convenience of attachment of the tail block; along this portion of the webs the thickness of the metal is 2½ inches. They rest on, and are secured to, 12-inch cross-girders, which are bolted to masonry foundations. The top flanges are held in line by cast-iron brackets *G*.

The tail block *A* is a steel casting, which may be attached to the girders, at intervals of 18 inches, by two short steel pins, on either side, 6½ inches in diameter, and any intermediate adjustment is obtained by four geared steel nuts *C*, working on rods D^2. These nuts are turned by a central pinion on the shaft *E*, the nuts, pinion and shaft being contained in the plate-box *F*.

The connecting block B^2 is a slotted steel casting resting on wheels, and attached to the tail block *A* by four steel rods D^2, 5⅝ inches in diameter, having the adjustment at *F* above described. Provision is made for recoil by a steel rod, *H*, fastened to B^2, and passing through a brass friction-clamp, *I*, in the tail block. It will be observed that the rods D^2 are held fast in the block B^2 by double nuts, while they are free to push through the tail block *A*. The effect of recoil at this end is therefore controlled by friction upon the rod *H*, and the amount of the friction required for that purpose is regulated by adjustment in the clamp *I*.

A vertical slot, disposed centrally between the rods D^2, admits the head of the eye-bar, which is secured by a pin passing through a pin-hole 7½ inches diameter, and slotted 1½ inches. When smaller pins are required, collars are added to fill. The object of this elongation of the pin-hole is to admit of recoil in the test piece itself—a not inconsiderable quantity in large bars. This recoil is taken upon a wooden block placed between the back of the slot and the end of the eye-bar.

Plate III.



1,200,000 LBS. TESTING MACHINE

SECTION SHOWING PACKING OF PISTON.

The connecting block *B* is similar in all respects to B^2, except in that it is attached to the piston by rods *D*, of same size as D^2, the recoil in this instance being transmitted without injurious effect upon the piston.

Plate II is an enlarged view of cylinder head and piston, showing the copper-wire packing between head and barrel, also the piston and piston-rod packing, and the connection of cylinder with main girders.

Water is delivered from the pump through the pipe *P*, 3 inches diameter, and is discharged through P^2, of the same diameter, into a tank outside the building. The vertical distance from center of the cylinder to the surface of the water in this tank is 4 feet 6 inches.

Plate III illustrates on still larger scale the detail of the piston packing. A sample of the packing itself is also submitted with the paper; it does not differ from that in general use, and is too well known to require description. This packing is "set up" by a brass gland and packing bolts, with thread and nut adjustment, until

the leakage, under maximum pressure, is reduced to a thin film of water discharging uniformly about the periphery of the piston. After a test has been completed and the piston remains at a distance from the head of the cylinder equal to the stretch of the piece, it is brought back to a normal position by opening the discharge cock in the pipe P^2, and allowing the water to pass out under the head of 4 feet 6 inches, when it is found that the partial vacuum thus obtained, which is equivalent to 1½ pounds per square inch upon the piston, is sufficient for the purpose. This is equal to about three thousand pounds total pressure, and, inasmuch as the pressure upon the packing when properly adjusted by its gland for a maximum water pressure is believed to be a constant quantity, it is assumed that three thousand pounds represent the maximum reduction which should be made as compensation for frictional resistance. This is scarcely one-quarter of one per cent. of the highest strain indicated by the gauges, and for all practical purposes it may be disregarded.

Pressure is supplied in the cylinder by a pump having three single-acting plungers, 2¼ inches diameter and 10-inch stroke, working at slow speed, and giving steady and uniform movement to the piston. An engine having two cylinders, 8 inches diameter by 8 inches stroke, is sufficient to work the pumps with such regularity that little or no fluctuation is noticeable in the gauges.

In operating the machine, the tail block *A* is attached to the web of the girders at the nearest range of holes corresponding to the length of test piece; the block B^2 is adjusted to exact position by the spindle *E*. The test piece is lowered into the slots by an overhanging traveler, and when the connecting pins are driven the pressure may be applied. Upon starting the pumps the gauges begin to rise at a uniform rate, and continue until, for a moment they cease to move, which fact is assumed as indicating permanent set. After this limit is passed the advance is at a gradually decreasing rate until the ultimate or highest pressure is reached; at this point they remain stationary, or with very slight vibrations, often for a considerable time, the stretch in the piece meantime continuing with increasing rapidity. When the stage of actual rupture is initiated the gauges begin to fall, slowly at first, afterwards with rapidly increasing rate, until the piece is broken. In order to prevent injury to the gauges by the sudden reduction of pressure at this instant, small check valves are placed in the supply pipes just under the gauges. They are light, and close by gravity, allowing the pressure to be relieved gradually.

The effective length of the cylinder being, as already stated, 4 feet 11 inches, it is possible to stretch a specimen to that limit before withdrawing the pressure in order to set back the tail block. This represents 12 per cent. stretch for an eye-bar 40 feet long, which is the limit of the machine, and for a great majority of cases this range is in excess of the ultimate strength.

Under the maximum pressure for which the machine has been designed, the principal members are subjected to initial strains up to the following limits:

Main girders.....	7,100	pounds	compression	per	square	inch.
Steel castings.....	15,000	"	"	"	"	"
" "	13,000	"	tension	"	"	"
" connectings rods	15,000	"	"	"	"	"
" bolts.....	12,000	"	shear	"	"	"

All strains are referred to the net or effective sections, and this margin of safety appears to be sufficient to provide against injury from the sudden release of strain at the moment of rupture of test piece.

A fragment of a steel bar, 8 by 1 15/16 inches section, which has been tested to rupture on this machine is exhibited herewith; upon it will be found a full record of the test, in regular form, as follows:

WORKS:
ATHENS, PA.
Late Kellogg & Maurice.
Capacity, 14,000 tons.

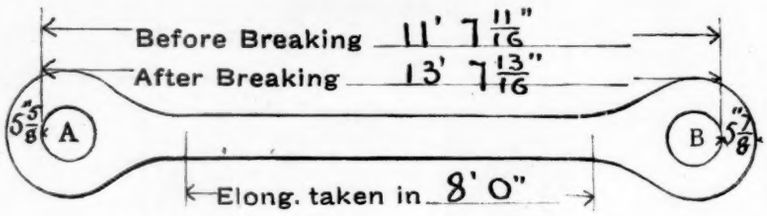
BUFFALO, N. Y.
Late Cent'l Bridge W'ks,
Capacity, 12,000 tons.

UNION BRIDGE COMPANY,
CIVIL ENGINEERS AND CONSTRUCTORS OF BRIDGES,
NEW YORK OFFICE, 18 BROADWAY.

Test No. 20.
Contract No....
Original Mark, M.

TESTING DEPARTMENT,
AT ATHENS, PA.,
October 29, 1886.

Full-sized test of Hawkesbury Bridge Steel Eye Bar, rolled by Steel Company of Scotland. Manufactured by Buffalo Shop, Union Bridge Company.



Head: Dimensions, 18 1/16 × 1.98 in. Excess, 41.4 per cent.	Head: Dimensions, 18 1/16 × 1.95 in. Excess, 45.7 per cent.
Diameter of pin-hole, 7.03 in.	Diameter of pin-hole, 6.52 in.
Elongation of pin-hole, 1.18 in.	Elongation of pin-hole, 1.60 in.
Nominal section, 8 × 1 15/16 in.	Actual section, 8 × 1.93 in.
Original area, 15.44 sq. in.	Fractured area, 6.22 × 1.20 in. = 7.464 sq. in.
Gauge reading for elastic limit.... ...273 = 556,815 pounds.	
" " ultimate strength, 503 = 1,025,920 "	
Elongation in 12 in., 4½ in.	Elongation in 8 feet, 1 ft. 1 7/8 in.

Elastic limit	36,063 pounds per square inch.
Ultimate strength	66,445 " " " "
Elongation in 12 inches	37.5 per cent.
" 8 feet	20.76 "
Reduction of area at fracture	= 51.65 "

Fracture fibrous and silky, excepting little fine crystal on edges.

REMARKS.

Elongations in 8 spaces of 12 inches each:

(A) 1 ft. 11 5/8 in. + 1 ft. 1 1/8 in. + 1 ft. 2 in. + 1 ft. 1¾ in. + 1 ft. 2 in. + 1 ft. 2 5/16 in. + 1 ft. 2 1/8 in. + 1 ft. 4½ in. fracture + 1 ft. 2 3/8 in.

This material was required to stand 67,000 to 74,000 pounds per square inch on sections of ¾-inch diameter.

UNION BRIDGE COMPANY,
By MILLARD HANSIKER, Inspector.

From this it appears that the maximum strain applied was 1,025,920 pounds, or 66,445 pounds per square inch on original area of 15 44/100 square inches. The remaining portion of this bar has been sent to Mr. B. Baker, M. I. C. E., in London, as a specimen of the material and workmanship for the Hawkesbury Bridge, for which tests were required.

Numbers of bars, ranging in section from 5 to 18 square inches, have been tested with similar results, and without

the slightest injurious effect upon the machine. The largest bar thus far strained to rupture was 8 by 2¼ inches section by 14 feet 10 inches between bearings on pins, the material being open-hearth steel, specified to stand 67,000 to 74,000 pounds per square inch on small specimens, ¾ inch diameter. In this case the maximum strain was 1,187,000 pounds, or 66,539 pounds per square inch on the original area. Two steel bars, 8 by 2⅜ inches in section, have been strained up to 1,223,760 pounds without causing rupture, when it was thought prudent to discontinue the tests.

It has been previously stated that, at the moment of rupture, a considerable reduction of strain is indicated by the gauges. A few observations of this reduction have been made; and, as a matter of interest, it may be stated that, in the case of the fragment exhibited, the strain per square inch at the moment of fracture, referred to the original area, was 57,464 pounds per square inch, as against 66,445 pounds maximum indication before final reduction began. If the area at point of fracture be considered, the actual strain upon that area was 118,867 pounds per square inch.

Your attention is called to the flow of metal at the zone of fracture, to the elongation of pin-hole, and in fact to the general appearance of the fragment as a whole, indicating, as it does, far better than any mere verbal description, the capacity of the machine.

At the present writing its sphere of usefulness is limited to the testing of tension members, not exceeding 40 feet in length, to a maximum strain of 1,200,000 pounds. The largest pin-hole provided for eye-bars is 7½ inches diameter, but flats, rounds and squares can be tested without pins by a simple attachment to the connecting blocks. When the plans for applying compressive strains are perfected, it will be possible to test specimens up to 32 feet in length and 800,000 pounds pressure.

The machine was designed by Mr. Charles Kellogg, Member of the Society. The late Mr. J. L. Marsh rendered valuable service to Mr. Kellogg in the preparation of plans and in superintending the construction. His death occurred immediately after its completion.

It is not contended that this is an instrument of precision, as for experimental research, or that in sensitiveness or minute accuracy it is the equal of the United States testing machine at Watertown Arsenal. Mr. Kellogg himself would be the last person to invite comparison in that respect with the superb invention of Mr. A Emery. What he has accomplished has been the construction of a machine, at moderate cost, which will test to destruction full-sized sections, as they are required for structural purposes, with rapidity and reasonable accuracy, of which the records submitted are sufficient evidence.

In reply to an inquiry regarding the Watertown machine, the writer has been favored with the following information by F. H. Parker, Major Ordnance Department, U. S. A.

"A description and account of the machine is published in the Annual Report of the Chief of Ordnance, U. S. A., for 1883. From that you will see that the capacity of the machine is 800,000 pounds for tension tests and 1,000,000 pounds for compression. In the combination of the qualities of accuracy, sensitiveness, and convenience of manipulation, it is believed to stand alone, and precautions have been taken to prevent injury by recoil or reaction.

"The machine is continually operated not only in testing large members of structures, but also small band specimens where the greatest accuracy is desired; and it is necessary to use it in such a manner as will in no degree impair this latter quality.

"The machine has frequently broken bars to nearly its full capacity; but, in view of the constant demands made for accurate work in testing cannon metal, and in making tests for industrial purposes, it is not thought advisable to run any risks of injury or delay by breaking bars of great length and large cross-section combined. The testing of such bars is carried far enough to give, probably, all useful information required.

"Government work on the machine occupies a great deal of the time; but considerable work for private parties is done."

From all of which it would appear that the magnificent piece of mechanism from which we had hoped to derive such valuable information, which was so admirably described by the late A. L. Holley, M. Am. Soc. C. E., in a paper pead before the Institute of Mining Engineers, Vol. VII., 1879, and for which not a few of our Members devoted valuable time and "influence" at Washington in quest of an "appropriation," is, in all probability, destined to occupy an honorary position in engineering science, and will be quite beyond the reach of engineers in the active practice of their profession.

Perhaps this is a consummation for which we should be devoutly thankful. It is un-American, to say the least, to approach the General Government for assistance, except in such cases as may be fairly considered beyond the reach of individual enterprise. It was thought at the time of the agitation for a Government testing machine, that the great expense of its construction was a sufficient reason why it could not be undertaken by private means, and this was true so long as the question was complicated by a desire to secure an instrument which was alike suited for laboratory experiments and the testing of large sections. It was a mistake, however, to attempt the construction of such a machine. The two lines of investigation are separate and distinct, requiring mechanical appliances differing as radically as do the amounts of applied strain; hence it would have been far better, and cheaper in the end, to have have built two machines, one of which should be adapted to delicate work upon small specimens, and the other of sufficient power to develop the strength of full-sized members without attempting to secure minute accuracy in the measurement of ultimate strains.

In this connection, engineers are more particularly interested in the working properties of structural material in its completed form; and a machine which will develop these properties expeditiously, and at moderate cost, commends itself, without inviting invidious comparison with others having different objects in view.

THE new railroad mileage built last year, according to statements recently published, reached 8,100 miles, a total which has been heretofore exceeded only twice. The greater part of last year's new mileage was west of the Mississippi river, both the Northwest and the Southwest coming in for a share. The building of parallel lines, which has, for the present, practically ceased in the Eastern states, is now very active in the West. Much of this is due to the rivalry of the great Chicago and St. Louis companies, and their fear of losing business should a competing line be the first to take the business of a new district.

Resistance of Trains on Railways.*

BY — DESDOUITS.

(*Annales des Mines*, 8ª Serie, Vol. viii., 1885, p. 481.)

IN this article the author gives the results of a long series of experimental investigations of the resistance of locomotives and trains on railways.

The resistances due to the rolling of the wheel-flanges and the sliding of the axles on the bearings are taken together as the resistance to rolling, the one and the other element being taken as proportional to the load, and the joint resistance being taken at so much per ton. But the resistance of the atmosphere varies in wide proportions, not with the load, but with the forms and the grouping of the vehicles. Besides, the element of atmospheric resistance considerably preponderates in the composition of the total resistance, for high-speed trains at least.

From a geometrical point of view, trains of all kinds belong to one of two classes—passenger trains and goods trains. The first are regularly and compactly formed, the second are irregular and more widely connected. The elementary train, as it is called—engine, tender, and brake-van—is the first submitted to experimental investigation. For resistance at very low speeds, when atmospheric resistance is a minimum and may be neglected; and afterward at high speeds when the law of atmospheric resistance may be determined. For each experiment the engine is in steam, and the regulator is slightly opened, so as to obtain a conveniently low initial speed of from 3¾ miles to 5 miles per hour (6 to 8 kilometers); then the steam is shut off, and the stopping of the engine, by its own proper resistance, is observed. The four series of engines in regular service have been submitted to experiment, of which the leading features are here tabulated:

Designation of Locomotive.	Axles.	Wheels. Diameter. Ft. Ins.	Cylinder. Diameter. Ins.	Cylinder. Stroke. Ins.	Weight. Engine. Tons.	Weight. Tender. Tons.	Weight. Total. Tons.
1. High speed..	3 axles, 2 coupled	6 7½	17.3	25.6	36	16	52
2. Mixed speed.	3 " coupled	4 11½	16.5 / 18.5	23.6	32	16	48
3. Goods speed.	3 " "	4 4	17.7	25.6	36	16	52
4. Goods speed.	4 " "	4 2	21.3	26.0	54	16	70

The cylinders of all these engines are outside. The high-speed engines have the Stephenson link-motion, with valves of two kinds—ordinary slide and cylindrical.

The mixed engines have ordinary slides. The three-axle goods engines have the same, and the four-axle engines have cylindrical valves.

A dynamometer of special construction, with pendulum movement, was fixed on the platform of the tender. The regulator was gently opened, so as to give a speed of about 6 miles per hour; then suddenly closed, when the engine was left to come to a state of rest, without the use of the brake on the tender. A diagram of uniform resistance was described. The observation was repeated three or four times backward and forward on the same piece of line, making a passage of from 110 yards to 160 yards. According to another system of observation, the time taken for each revolution of the driving-wheels in the course of the run was noted, and thence the speed and the retardation were calculated

* From Abstracts of Papers in Foreign Transactions and Periodicals, published by the Institution of Civil Engineers.

It is of essential importance that the state of the experimental way should be, if not perfect, at least in average condition, as for a portion of the main line. This condition is often but imperfectly realized in stations and goods yards. The locomotive, also, should be in at least average good order, working freely, stuffing-boxes not unduly tight, bearings free, lubrication good, tender-brake quite clear. The engine should have made a run since being lighted up, in order to bring all the moving parts into a proper state of lubrication, and to their normal temperature. An engine cold, and taken direct from a state of rest, though well oiled, usually has a surplus of resistance of from 30 to 50 per cent. Newly repaired engines have shown nearly double the normal resistance.

The state of the atmosphere affects the resistance. A head wind of 16 feet per second would suffice to double the resistance at a speed of 5 miles per hour. The resistances are deduced from velocities diminishing from 5 miles to 2½ miles per hour.

From the detailed tables given of the observed resistances of the engines tried, the following summary of the resistances in pounds, per ton of gross weight of engine and tender, has been prepared:

Designation of Engines.	Resistance per ton of Engine and Tender. Slide-Valves. Stephenson Link. lbs.	Cylindrical Valves. Stephenson Link. lbs.	Cylindrical Valves. Walchaërts Gear. lbs.
1. High speed.....	6.94	....	5.82
2. Mixed.....	8.06	8.05	....
3. Goods (three-axle).	10.53	....	....
4. Goods (four-axle)..	....	....	9.18

It appears that the engines fitted with cylindrical valves and the Walchaërts gear have a marked advantage over those of the ordinary type of gear. Comparing the two high-speed engines, there is an advantage in reduction of resistance with the modified gear of 1.12 pounds per ton, or 16 per cent. Again, the four-axle goods engine, having the modified gear, has 1.34 pound per ton less resistance than the three-axle goods, although the four-axle engine has the smaller wheel, and the larger dimensions of cylinders and mechanism. The mixed engines have equal resistances of about 8 pounds per ton. In this case the transformation was only partial, and with the introduction of the cylindrical valves the old Stephenson gear was retained, and it was constructed with a return movement. The diameter of the cylinders, also, was augmented.

These causes of supplementary resistance are compensated by the modification of the valve-gear.

The resistances above announced are noticeably less than those which are generally assigned to like engines, according to earlier experiments. The difference probably arises, for the most part, from the higher speeds at which these were made.

RESISTANCE OF THE MACHINERY OF LOCOMOTIVES.

Experiments were made with a high-speed engine, a mixed engine and a four-axle engine. For each experiment an auxiliary engine in steam was employed to get up the speed of the engine on trial—from 4 to 5 miles per hour—afterward putting on its brake. The retarded movement of the engine was then noted. The reverse movement was given by a second auxiliary engine. Each engine in working order was also tried in steam. The results are here tabulated as follows:

MACHINERY—RESISTANCE.

Designation and Condition.	Resistance per ton. Pounds.	Total Resistance. Pounds.
1. High-speed engine, with flat slide-valves, entirely mounted, in steam (weight, including tender, 52 tons)	7.17	373
The same engine, connecting-rods, valve-gear and coupling-rods dismounted	5.26	274
Say, for all the movable pieces	1.91	99
2. Mixed engine, with flat slide-valves, entirely mounted, in steam (weight, including tender, 48 tons)	8.06	387
The same engine, connecting-rods and valve-gear dismounted	5.04	242
Say, for the mechanism	3.02	145
The same engine, with the connecting-rods, coupling-rods and valve-gear dismounted	4.93	236
3. Goods engine, four-axles coupled, with cylindrical valves, entirely mounted, in steam (weight, including tender, 70 tons)	8.96	627
Same engine, connecting-rods and valve-gear dismounted	6.94	486
Say, for the mechanism	2.02	141
Same engine, connecting-rods, coupling-rods, and valve-gear dismounted	6.94	486

These results show that the mechanism absorbs from 27 to 22 per cent. of the whole resistance of the engine. For the mixed engine and the four-axle engine the resistances are nearly the same. The influence of the coupling rods is scarcely appreciable.

RESISTANCE OF THE TENDER ALONE.

The results of trials made with tenders separated from the engines give from 5.60 to 6.27 pounds per ton for resistance, ranging about the same as that of the engines or carriages.

RESISTANCE OF PASSENGER CARRIAGES AND VANS.

From the results of trials with trains of seven and eight vehicles lubricated with colza oil and with mineral oil, the resistance was at the rate of 3.47 pounds and 3.58 pounds. The wheels were 3 feet 5 inches in diameter, with journals 3½ inches by 7 inches, and loaded to 4 and 5 tons, respectively, per axle. The temperature during the trials was 59° Fahrenheit.

RESISTANCE OF GOODS WAGONS.

A train of thirty wagons, weighing in gross 300 tons, was tried. It was lubricated with colza oil, having wheels and journals like those of the carriages. The resistance of the engine, tender and train—the engine and tender weighing 70 tons—was at the rate of 4.93 pounds per ton, or for the train, separately, 4.10 pounds per ton.

It is concluded generally for all sorts of vehicles under conditions of lubrication like the vehicles tested, that a resistance without speed of from 3.36 to 4.03 pounds (1.50 to 1.80 kilograms per tonne) per ton may be accepted with an extreme limit of 4½ pounds per ton. Greater resistances than these arise from defective lubrication or atmospheric resistance.

RESISTANCES AT HIGH SPEEDS: ATMOSPHERIC RESISTANCE.

Experiments were made on the resistance of the air to flat boards suspended laterally from a train, movable on axles and counterweighted. The train was run at increasing velocities, and the instant was noted when the resistance of the air, preponderating, caused the lifting of the weights and reversal of the board. It was deduced from experimental results that (1) the resistance on a surface 1 decimeter square (3.94 inches square), in absolutely calm weather, at a speed of 44½ miles per hour, amounted to 0.52 kilogram, or 1.14 pound, being at the rate of 106 pounds per square foot.

For other velocities the variation of resistance is sensibly as the square of the speed; and within practical limits, the extent of the surface does not sensibly affect the coefficient of resistance.

The resistance to pressure may be reduced one-half by the adoption of angular prows. A locomotive was fitted with angular prows on the smoke-box, buffer-beam, footplate fence and other parts. The back of the tender was fitted with an angular tail-piece, and the wheel spokes were covered in with sheet-iron. The resistance, at a speed of 43½ miles per hour, was by means of these fittings reduced 9 pounds per ton. This engine, thus fitted, was kept on regular duty for a period of six months working omnibus trains. The results, compared with the average results from four engines of the same class in ordinary condition, were as follows:

	Average Tonnage. Tons.	Consumption Per Mile. Pounds.
Four engines in average condition	93	22
Modified engine	94	19

showing an economy of about 14 per cent. in favor of the modified engine.

The author proceeds to develop formulas for the resistances of engines and trains at high speed. He recognizes the principle of the variation of all the resistances as a whole, as the square of the speed.

Her Majesty's Ship "Narcissus."

THE London *Times* gives the following description of a new belted cruiser, which was launched on December 15th, which will be of interest in this country at the present time, when we are thinking a good deal about war ships:

"The vessel is 300 feet long on the load-line, has a breadth of 56 feet and a molded depth of 37 feet, with a draught of about 21 feet. Protection is afforded by a belt of steel-faced armor, 10 inches in thickness, extending the whole length of the boiler and magazine space, thus protecting the most vital parts of the ship. The *Narcissus* has been built in ram form, her ram being of steel, the latest arrangements being adopted for strengthening and stiffening. Her stern-frame is also of cast-steel, and, with the ram, was supplied by Messrs. Jessop & Son, of Sheffield, while the crutches for the twin propellers, also of steel, are by John Brown & Company, Sheffield. With regard to the armor belting, it may be stated that it is 200 feet in length, extending from 1 foot 6 inches above the water-line to 4 feet below. This belt of 10 inches is backed with 6 inches of teak, secured in steel plating 1 inch thick. On a level with the top of the belt there is a protective deck, which extends the whole length of the vessel. In the way of the belting this deck is perfectly horizontal, and is formed of steel plating 2 inches thick. Beyond the belting, the deck is declined downward to an angle of 30°, and it is here 3 inches in thickness, so that fore and aft a sort of turtle-back is formed. All the openings in this protective deck are fitted with either armor shutters or shell-proof gratings. By means of the armor

belt amidships, and the protective deck-plating fore and aft, the whole of the vessel under this deck is rendered invulnerable to shot and shell, and forms an unsinkable raft, in which are placed the engines, boilers, magazines, shell-rooms and steering gear. When in action, the movements of the machinery, the steering of the ship and the firing of the guns are under complete control from the conning tower or pilot house, a massive structure at the fore end of the vessel. The look-out men in this tower are protected by 12-inch steel-faced armor, and all the communications to the engine-rooms, magazines, steering wheels, etc., pass through a tube of steel, 8 inches thick. It will thus be seen that everything possible is done for the protection of the crew, and to insure the safe working of the ship when in action. The hull of the vessel is of Siemens-Martin steel, and, altogether, there are over 100 water-tight compartments. As a still further protection to the ship, she is built on the double-bottom cellular principle, and has provision for water ballast, fore and aft, for trimming the vessel. The vessel has steam steering-gear, and the whole of her machinery is placed under the protective deck, and steam connections will be made to the conning tower forward and the lower deck forward, while hand steering-gear will be placed on the protective deck aft. The berthing of the crew, about 420 all told, will be similar to that which is common on board the vessels of Her Majesty's Navy. The lines of the vessel are specially designed for a high rate of speed, about 19 knots it is expected, and altogether she presented, as she went afloat, a very beautiful appearance.

"The armament of the *Narcissus* consists of one 10-inch breech-loading gun in the center of the citadel. This powerful gun is mounted on Vavasseur's center-pivot automatic carriage with a central hoist for passing up the ammunition by steam-power close to the breech, no matter in what direction the gun may be trained. There are also in the citadel five guns on each side of the ship, each 6 inches, similarly mounted to the central gun. Each of the end guns is on a sponson, so that it can be trained, the forward ones right forward and the after ones right aft, in a line with the ship. When the ship is in action, the protective deck can be cleared of all obstruction, the stanchions, bulwarks, bollards and everything being so arranged that they can be laid flat on deck. On the 'tween decks there are ten of the Hotchkiss quick-firing guns. In the center line, still on the 'tween decks, there are two 9-pounder guns, one forward and the other aft. The vessel will be rigged with two jury-masts with tops, sufficiently spacious to allow of the working therefrom of machine guns.

"The engines, which are also being constructed by Earle's Company, are of the horizontal, direct-acting, triple-expansion type, the diameter of the cylinders being: high pressure, 36 inches; medium, 51 inches; and low pressure, 78 inches; with a length of stroke of 42 inches. The surface condensers are all of brass and provide a cooling surface of 12,000 feet. The frames of the engines are of steel, and the crank-shafting of Whitworth's fluid compressed steel, a portion of the shafting being hollow. The pistons and piston-rods are also of steel, and the connecting-rods of wrought-steel. The engines are fitted with steam gear for starting, reversing and turning. The air-pumps and all connections are of gun-metal. The circulating pumps are of gun-metal, and are driven by independent engines fitted with additional suction valves leading into the bilges, so that they may be used for pumping water out of the ship in the event of a leak. Each circulating pump is capable of discharging 500 tons of water per hour. There are also in the ship two of Normandy's condensers capable of condensing 130 gallons of water per hour, for the use of the ship's crew. Steam is supplied to the engines by two double-ended steel boilers, each 14 feet 6 inches in diameter by 17 feet 6 inches long. At each end there are six of Fox's corrugated furnaces, and the working pressure is 130 pounds to the square inch. The propellers are of gun-metal and are 14 feet 6 inches in diameter."

New British War-Ships.

Two new "belted cruisers" have recently been built and launched, one, the *Undaunted*, by the Palmer Shipbuilding and Iron Company, Jarrow; and the other, the *Australia*, by Messrs. Robert Napier & Sons, Govan.

The *Undaunted* is described as follows in the London *Times*:

"The principal characteristics of this type of vessel are, briefly, a high attainment of speed with great defensive power. They are more like the *Mersey* class than any other, the chief difference consisting in a belt of armor about the water-line which is fitted in the *Undaunted* class, and from which they derive the name of belted cruisers. The following is a general description of the vessel: Length, 300 feet; breadth, extreme, 56 feet; depth, molded, 37 feet; normal draught, 21 feet; displacement, 5,000 tons; indicated horse-power, 8,500; estimated speed, 19 knots. The armor is compound or steel-faced, and consists of a belt 200 feet in length, extending from 1 foot 6 inches above the water-line to 4 feet below. This belt is 10 inches in thickness, and is backed with 6 inches of teak, secured in steel plating 1 inch in thickness. On a level with the top of the belt there is a protective deck, formed of 2 inches of steel plating. Beyond the belt at both ends the deck is inclined downward to an angle of 30°, and is 3 inches in thickness. All openings in this deck are fitted with either armor shutters or shell-proof gratings, and those necessarily open in action are also fitted with coffer-dams. By means of the armor belt amidships, and the protective deck-plating fore and aft, the whole of the vessel under this deck is rendered invulnerable to shot and shell, and forms an unsinkable raft in which are placed the engines, boilers, magazines, shell-rooms, and steering gear. When in action, the movements of the machinery, the steering of the ship, and the firing of the guns are under complete control from the conning tower, a massive structure at the fore end of the vessel. The look-out men in this tower are protected by 12 inches of steel-faced armor, and all the communications to engine rooms, magazines, steering wheels, etc., pass through a tube of steel 8 inches thick. The stem, which forms a ram, is exceptionally strong and is well supported by the framework of the vessel and the protective deck. The ram, sternpost and propeller brackets are each of cast-steel, manufactured by Messrs. Spencer & Sons, of Newburn. The hull is built of Siemens-Martin steel, and is divided into over 100 watertight compartments.

"The *Australia* is one of five belted cruisers ordered in April, 1885. The building of two, the *Australia* and the *Galatea*, was intrusted to Messrs. Napier & Sons, two, the *Orlando* and the *Undaunted*, were ordered from

Palmer's Shipbuilding and Iron Company (Limited), Jarrow-on-Tyne, and the fifth was ordered from Earle's Shipbuilding Company, Hull. The *Australia*, like her sister ships, is 300 feet long between perpendiculars and 56 feet in extreme breadth. The draught of water, under ordinary circumstances, will be 19 feet, and, at this draught, the displacement will be 5,000 tons. This may be at times increased to 6,000 tons, when a full supply of coal is shipped. It is expected that the vessel will have a speed of 18 knots per hour. The engines, which are to be fitted on board, and have been designed by Messrs. Napier, are of the triple expansion type, working twin screws, and will indicate 8,500 horse-power, the working pressure being 130 pounds. It may be interesting to mention that when tenders were asked for vessels of this class, compound engines of 7,500 horse-power were specified, but Messrs. Napier proposed, as an alternative scheme, to fit triple expansion engines on board, and undertook to develop 8,500 horse-power, and that without taking up any more room in the ship or increasing the collective weight of the machinery and coal. The Admiralty accepted this proposal, and carried it out in the other ships of the class. The result will be to increase the speed by about a knot per hour, while less coal will be consumed. The boilers are of the double-ended multitubular type, and have corrugated flues. The armament will consist of two very long range 9¼-inch Armstrong guns, ten 6-inch guns of the same class, all mounted on central-pivot Vavasseur mountings, eight 6-pounder and eight 3-pounder quick-firing guns, also six torpedo impulse tubes. The two striking characterics of the ship are her high rate of speed and length of gun, or range of fire. These qualities would generally enable her to overtake an enemy, or to avoid one altogether if too heavy metal for her; or, using her great speed, she might keep the enemy within the range of her big guns, while she herself was beyond the enemy's fire. Every safeguard has been adopted to shield her from the enemy's fire, and to prevent her from sinking. She is divided into about 130 compartments or cells. The engines and steering gear are all under the water-line, and are protected from *débris*, and from dropping fire, by a 2-inch thick steel deck extending the whole length of the ship. The water-line of the ship is protected by an armor belt 10 inches thick, steel-faced strongly supported by teak and steel backing, and capable of resisting a shot or shell from 10-inch guns."

The Waste of Water in Town Water Supplies.

(From *The Engineer*.)

WE have from time to time noticed the investigations of municipal engineers in connection with the waste of water and its prevention. When properly understood, the sum of all the information now available assumes a significance of which few but those who have made the investigations have the slightest idea. A recent report by Mr. Alexander R. Binnie, M. Inst., C. E., waterworks engineer to the Bradford Corporation, places the subject in a striking light; and it is important that Mr. Binnie's work in Bradford should be more widely known. Let us, however, in the first instance, say that this subject of the waste of water and its advocated suppression is not, as appears to be too often ignorantly supposed, the outcome of any desire for niggard supply or parsimonious use. Precisely the opposite view has been consistently held by those who have been most energetic and successful in the suppression of waste. All that is demanded is that so far as possible the water shall be led without waste *to* the consumer's fittings, where he may draw to his heart's content.

Thus, Mr. Binnie, in his recommendations to the Corporation of Bradford, pointed out last year that "by the prevention of waste is not to be understood that it is either contemplated or desired to deprive our customers of one drop of water which they can reasonably or even lavishly require for any useful purpose. Briefly, it may be summed up as an attempt to stop that continual flow of water which is always going on in large towns, and which, in a great measure passes through the pipes not only without doing good to any one, but in many instances in a manner quite unknown and unthought of by the great bulk of the consumers." And again, in 1882, Mr. Deacon, who had been so signally successful in suppressing the waste in Liverpool, and introducing constant supply with great financial benefit to the Corporation, said at the Society of Arts: "The prevention of the waste of water is not, in any sense, a restriction of the use or misuse of water by the consumer, but may even conduce to the greater use or misuse by rendering the water more readily available, under high pressure, and at all times. Not that misuse is a good thing, but that absolute absence of restriction is, I think, a good thing. It would be better to allow a gallon to be misused than, even if there were the power—which there is not—to prevent it, to restrict the proper employment of a pint."

It is, in short, no part of the water authorities' business to inquire how the consumer uses the water, subject, of course, to his not employing it for trade purposes. It is the authorities' duty to lay the water on, and to maintain a high and constant pressure; and it has been shown beyond all question that this can be done with profit to the authorities, and without any interference with the consumer, even to the extent of entering his premises, unless unnecessary waste, previously ascertained by external means, is actually taking place within those premises.

"It is," says Mr. Binnie, "eleven years since I began to urge the necessity of some effective steps being taken to prevent the waste which I at that time proved to be going on." But it was not until August, 1885, that the Corporation of Bradford determined, upon his recommendation, to institute a proper and efficient system for the prevention of waste of water. In his report of October 1st, 1886, giving the results of his first thirteen months' work, Mr. Binnie writes concerning the prevention of waste: "The system which you determined to adopt to effect this latter object was arrived at after an inquiry as to what had been done in other towns, and an experimental trial extending from October, 1884, to July, 1885, the result of which was fully described in my report to you dated the 14th of August of last year. The system on which you determined to work may be briefly described as cutting the town up into a series of small districts, the water supply of each of which is made to pass through one of Deacon's self-recording meters, which registers on a diagram from minute to minute, and from hour to hour, the water passing through it." The meter in question and Mr. Deacon's method have been frequently described, and it is only necessary here to point out that the most important features of the instrument are the two following. (1) That inas-

much as the water way increases as the flow increases, there can be no appreciable loss of head, so that the instrument may be placed in the line of any water-main without in any degree—capable of determination by ordinary pressure gauges—restricting the flow. (2) That the differential diagram drawn by the meter enables one to distinguish between water wasted and water drawn for use. The latter being a steady, uniform flow, produces a steady line of uniform volume; and the former being a constantly varying flow, produces an irregular line of varying volume. Towards midnight the irregular flow rapidly diminishes, and a steady line becomes visible; not yet a line of uniform volume, however, for cisterns are still filling, and the line, steady though it may be, gradually curves towards an asymptote of uniform flow. This asymptote is obviously, therefore, a true measure of the waste. For all practical purposes it may be regarded as coincident with the line of minimum steady flow.

"The amount of waste," writes Mr. Binnie, "having been determined, its source is next sought out, and detected by various expedients, such as night inspections, shutting off portions of the district to detect the particular street, or streets, in which the waste is going on; and afterwards, in a similar manner, each house is isolated until the exact locality of the waste is determined. No attempt is made to limit or control the free and ample use of water for all purposes, and I am happy to be able to say that the supply has been maintained at constant pressure during the whole of the past year." Mr. Binnie next proceeds to explain the results of his work in two districts, the first containing 81,038 persons and 40,643 taps. In this district the total supply of water before inspection was 1,821,200 gallons, or 22.47 gallons per head per day, which in many towns would be thought by no means high.

After inspection and repair the rate of supply was reduced by suppression of waste to 14.35, but there still remained waste, which was calculated from the diagrams to amount to 5.55 galls. per head per day, from which it appears that the 80,000 people of this first district draw off on the average less than 9 gallons per head per day, though the pressure is high and constant. It is not that the supply is limited, or that the employment of water is in any way restricted, but simply that with present domestic habits the people will not, or at all events do not, on the average, take more. We do not advocate the reduction of the water supply of any town to 9 gallons per head per day, or even to 15 gallons, which would cover the residual waste hitherto checked in the Bradford district, and which probably represents the fringe of waste that must always remain when the more palpable cases have been suppressed. It is essential that the supply should always be much in excess of the demand, as indeed it would be in almost every place in the kingdom, if the example of the Bradford corporation were followed After explaining the results obtained in other districts still more recently placed under the system, Mr. Binnie proceeds to report the cost of the work, concerning which he says: "Viewing it in the most unfavorable manner, and taking into account all items of expenditure up to date, including the experimental work noted in my last report, capital charges and working expenses,. it amounts to £3,675 9s. 1d. By this expenditure a saving of 472,602,000 gallons has been effected in one year, the value of which to the corporation is £12,799 12s. 9d. per annum, equivalent to a capital sum of £284,436." Thus, according to Mr. Binnie, the value of water saved in the first year is three and a half times the total capital expenditure involved in the purchase and fixing of all the necessary apparatus, including stopcocks outside the houses and the working expenses combined. Spreading this capital sum over twelve years, Mr. Binnie states that the cost per annum is £922, or about one-fourteenth of the annual value of the water saved. We have stated the Bradford results in some detail, not because they are more remarkable than those obtained in other places, but because they constitute the latest contribution to our store of information concerning the enormous benefits which may accrue to water authority and water consumer alike, by a proper and unprejudiced understanding of the subject and by energetic and systematic action; and we heartily endorse Mr. Binnie's congratulations to the Bradford corporation on the result of their first season's work, which, as he says, far exceeds his best anticipations. We shall look with much interest for the completion of this work, which, notwithstanding the great benefit already accruing, appears to be scarcely half finished.

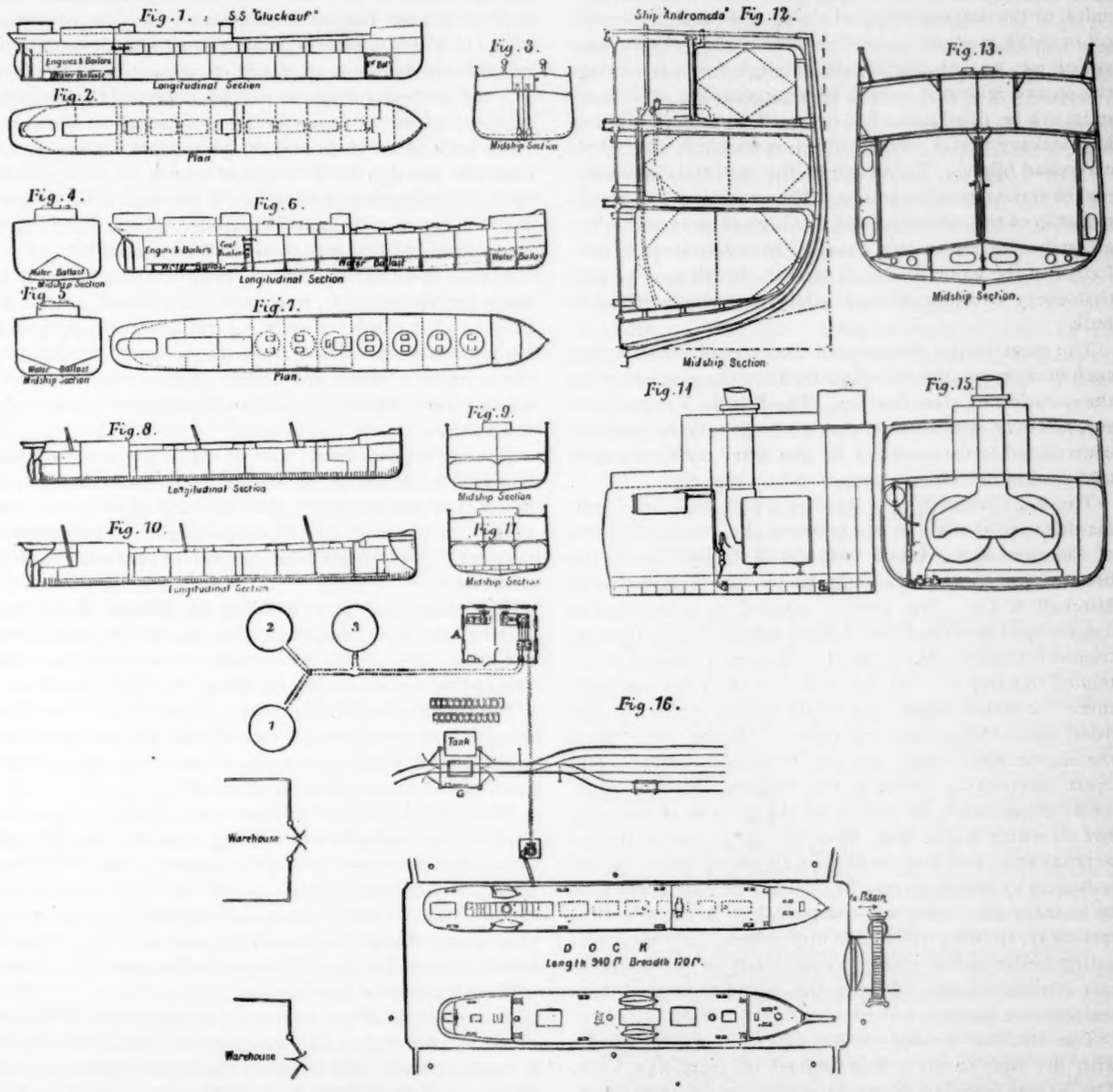
Petroleum Steamers.

On the 10th inst., an interesting paper was read by Mr. B. G. Nichol, on "The Use of Petroleum," before the North-East Coast Institution of Engineers and Shipbuilders at Newcastle-upon-Tyne. Mr. Nichol dealt chiefly with the composition of mineral oils and their heating efficiencies, and he described three different appliances for burning petroleum as fuel, those of Brandt, Sadler and Smith. This paper was followed by a communication from Mr. J. Gravell, surveyor of the Bureau Veritas, describing the most recent practice in the construction of petroleum-carrying steamers. In this communication the writer said that, having had the opportunity, in the capacity of surveyor to the Bureau Veritas, of inspecting the most recently constructed ship for the carriage of petroleum in bulk, viz.: s.s. *Glückauf*, during her entire construction, and again quite recently on the completion of her first voyage, he trusted that some description of her arrangements and their practical effect would not be without interest. Mr. Nichol, as an engineer, had pointed out the immense economic value of liquid fuel, as compared with coal in its calorific effect, its great superiority to coal for steamships in the reduction of labor in firing, in avoiding the necessity for cleaning fires and tubes, in the absence of ashes and scar, and in its requiring no trimming in bunkers. It also possesses special advantages in the promptness with which steam can be got up, and the facility with which the production of steam may be increased in emergency, or instantly diminished almost at will; in the absolute closeness of its stowage, and its adaptation for conveyance in such parts of the vessel as are, from their shape, not available for any ordinary description of cargo. To all these advantages, if we add extreme facility and small cost of shipment, also simplicity of measurement, it would appear that even at a considerably enhanced price, as compared with coal, mineral oil should be adopted whenever it can be obtained, as fuel for steamers.

There is, however, a prejudice against the use of liquid fuel, arising from the idea that it is not easy to make com-

partments tight enough to carry mineral oil in bulk, some shipowners being much affected by vague fears of explosion from leakages and gases which, on account of their vagueness, are very difficult to meet.

The influence of prejudice is clearly shown in the facts brought out in a very able, and (at its date) exhaustive paper read by Mr. B. Martell, on July 27 last, at Liverpool, before the Institution of Naval Architects. He showed that many years ago the idea of carrying mineral oil in bulk was before the public; but after all these years the old and dangerous method of carrying it in casks has survived and keeps its hold on the bulk of the American trade at this moment, while the efforts at emancipation from the cask monopoly have given rise in succession to the tin-lined case, the small tank, the larger tank, the double-skinned ship, and at last to the most rational arrangement of all, the conveyance of the oil directly against the bare skin of the ship, without tanks and without extraordinary precautions of any kind. The saving derived from carrying petroleum in bulk is an accepted fact. A vessel similar in size to the *Glückauf* would take from three to four weeks to load a cargo of oil in casks, but with her present arrangements for carrying it in bulk, she can be easily loaded in three days, and even this comparatively short time might be much shortened if necessary. Again, the vessel now carries a sufficient quantity of oil to fill 23,000 barrels, whereas a vessel of exactly the same dimensions, specially built to carry petroleum in casks, could not show more than 12,120 barrels, about 52½ per cent. of the quantity carried in bulk.



It is hardly requisite to discuss the prejudice which exists against the carriage of oil in bulk, when compared with its carriage in casks, on the score of safety. Of course, it is necessary to take some precautions. For instance, it is important to avoid frothing the oil by allowing it to fall from a height into the receptacle provided for it, and likewise to avoid the churning action which would be produced by the movements of the ship if the compartments were only partially filled, both of which tend to produce gas and deteriorate the oil. It is necessary that the structure and workmanship of the com-

parments should be of a high class, so as to prevent leakage; and if leakage should occur, that it be confined to parts of the ship out of reach of the boiler fires. A provision is required to keep the compartments full, notwithstanding the contraction or expansion of the oil by change of temperature at sea, also for allowing the escape of any small quantity of gas which may be generated, and for the ventilation of empty spaces in the neighborhood of the oil tanks where gas could possibly accumulate. But comparing the facility with which all these matters can be provided for in a ship carrying oil in bulk, with the difficulty, or the impossibility, of doing so in a ship carrying oil in casks, it seems quite clear that if the present innovation was to substitute cask carriage for bulk carriage the outcry against it would be unappeasable. The cask must not be filled quite full or it will infallibly leak, and any leakage would necessarily run through the whole cargo and bilges. The ullage of the cask thus inevitably makes some churning action, The structure and workmanship of the casks must be of a high class to hold oil at all, and represents a cost equal to from one-third to one-fourth of the value of the oil carried. It will thus be seen that every consideration of safety demands carriage in bulk.

The great initial difficulty in the way of constructing such vessels, was the objection made to the single skin, on the question of classification. The Bureau Veritas Society, however, was satisfied that a vessel could be properly constructed to carry oil out to the skin, and encouraged that system, which now proves to be a success.

The s.s. *Glückauf*, is a steamer which has been built for this special trade to run between the petroleum ports of America (or the Black Sea) and Germany. She is the first of two sister ships built by Sir W. G. Armstrong, Mitchell & Co. The hold is divided by a middle-line longitudinal bulkhead, and further subdivided by thirteen transverse bulkheads; eight of these compartments are intended to carry oil. At the fore end there is a compartment for water-ballast, and water-ballast tanks are also fitted under the engines and boilers. At the fore part of the engine room there are two bulkheads, spaced 4 feet apart, intervening between the engines and the cargo. This compartment, or well, is for the purpose of receiving any oil which might leak from the cargo compartments or trunkways, and may be kept as an empty space, having provision by which it may be cleared of gas at any time by a steam jet. Each oil compartment is fitted with a trunkway, running up to the upper deck, forming a self-acting feeder to the main compartment as the temperature diminishes, and allowing the liquid to expand if its temperature should increase.

The *Glückauf* arrived on August 22, at Geestemünde, with her first cargo of best refined oil from New York. The oil was found to be in excellent condition in all respects, and gave the highest satisfaction. From the refinery at New York, the oil was run into the vessel at a temperature of 87° Fahr. On her arrival at the port of discharge, after sixteen days' voyage, the temperature was found to be reduced to 67° Fahr. The contraction of the oil due to this reduction of temperature was 0.86 per cent.

Figs. 1, 2 and 3, give longitudinal plan and midship section of s.s. *Glückauf*,

The arrangements of s.s. *Glückauf* are those patented by Mr. Henry F. Swan. Mr. Swan has also taken out a patent for another description of vessel, specially intended to carry a large amount of water-ballast, without its being necessary to utilize for this purpose any of the compartments intended for containing oil. If this were done by making the inner bottom flat, in the ordinary way, to contain a sufficient amount of water (say one-third of the vessel's cargo capacity), the result would be, that the center of gravity would be so low, that the vessel, when in ballast, would be a very bad sea-boat, and when laden with oil, the center of gravity, on the other hand, would be too high. To meet these points, Mr. Swan makes the inner bottom in an inclined form, as per section Fig. 4 or Fig. 5. Either form gives all the advantages of an ordinary double-bottom, but in many respects the form Fig. 4 is preferable, and it will be observed that unusual facility is given for repairs and examination, as a man can freely walk about in an upright position, instead of having to crawl through very irregular spaces as in the ordinary double-bottom, and which, if gas had accumulated, might become positively dangerous. (Figs. 6 and 7 give longitudinal section and plan of these vessels.)

In case the inner bottom has been utilized for carrying crude petroleum, or if, from any other cause, gas has accumulated, it can be entirely got rid of by simply pumping up the inner bottom, and continuing the pumping up the trunkways, which are opened to the upper deck, and which form a means of access to the interior of the vessel at all times.

The author may be allowed to say, that though it must be admitted it was a somewhat bold undertaking upon the part of the owners of the *Glückauf* to order this first vessel, yet the merit of her success rightly belongs to the eminent firm of shipbuilders in whose yard she was constructed.

The sister ship now building by Messrs. Armstrong, Mitchell & Co., is constructed on the same principle as the first. There is no cement in the bottom of these vessels in the way of oil, the oil filling the floor spaces.

Messrs. R. and W. Hawthorn, Leslie & Co., have now in course of construction two vessels for this particular trade, one of which is being built under the Bureau Veritas' special survey (Figs. 8, 9, 10 and 11).

These vessels are constructed with a double bottom, so that all the oil-tight work being done on straight and almost plain surfaces, in case of injury to the ship's bottom, the necessary repairs can be as easily executed as on an ordinary vessel. Fore and aft bulkheads are fitted throughout the oil compartments, and where there is only one bulkhead, a suction is fitted to either side to correct a list in loading or discharging.

In one design (Figs. 10 and 11), in order that two kinds of oil may be carried, the holds are divided amidships by a four-foot space, which also serves to carry up the trunks for access to the double bottom.

In the double bottom, transversely, there is a slight rise to cause a run to the suction, and to facilitate the clearing out of air and gas when the ballast is being run up, as the air-pipes are at the side on the highest part.

The expansion trunks are built on the deck. Perforated plates are fitted to prevent the oil moving in a body, and at the same time to allow it to expand into the hatch. Small air-pipes are fitted to the hatch covers; these may be closed when desired so as to give some control over the escaping gases.

The pumps on both these vessels are placed right for-

ward and on the tank-top, as it has been found difficult to lift petroleum any great height in hot weather, owing to the low tension of its vapor.

Fig. 12 shows the midship section of the ship *Andromeda*. This vessel was lately fitted with tanks in order to carry petroleum in bulk. She has made one or two voyages successfully, and delivered her cargo in good condition. This system does not (to the author's mind) compare favorably with that of carrying the oil out to the skin of the ship.

The author, in Fig. 13, submits to this Institution a plan of dealing with old vessels, to adapt them for the carriage of this liquid, which, he considers, will overcome some of the difficulties met with. The form of the ballast tank-top, he believes, is similar to the principle adopted by Mr. H. F. Swan. The sides of the oil compartment are made to form an inner skin to the ship, allowing a space between them and the skin to admit of easy access to all parts of tank for the erection or any necessary repairs. By adopting this plan, he thinks there will be a considerable saving in the first cost as compared with fitting tanks, and it will certainly make a far superior job as the carrying of the oil would entirely depend on new work, and further, the strength of the ship would be considerably increased.

Messrs. Boolds, Sharer & Co., of Sunderland, have recently built two small steamers for Russia (Figs. 14 and 15), fitted for the conveyance of oil in the bunkers as fuel for the ship's own use. The bunkers were fitted in part of the main hold, and also in the engine and boiler space; the bunker compartments extended to the skin of the ship, and were fitted on deck with manhole doors instead of hatches.

There can be no doubt that, for marine propulsion, and especially for ships of war, petroleum or mineral oil as fuel will be extensively used when more experience demmonstrates its advantages as compared with coal, and the author looks to see tank-hulks established at coaling stations, and its use restricted only by the limited supply.

It may be interesting to the members to give an idea of the arrangements at Geestemünde for discharging and storing the oil. This is shown on Fig. 16. A flexible pipe is jointed to the ship's side and reaches to a pump driven by a gas engine on shore. The engine-house is marked A. The pump delivers into the circular tanks marked Nos. 1, 2 and 3. The combined capacity of these tanks is 4,900. The house marked G is the weighing-house, where railway tank-trucks are both filled and weighed. The railway trucks are like our ordinary tank-trucks, and hold about 12 tons of oil. The oil is sent in these trucks to the interior, or to any point in the railway system of the continent, and is then unloaded into tank-carts, holding each about a ton, from whence it is retailed into the tanks of storekeepers or private customers. It is not intended that the oil carried in bulk should be casked at all, although, of course, for special cases this may easily be done.

The Silber Car-Lamp.

THE following description of this lamp, taken from a London paper, would indicate that, if its merits are not overstated, it would be worthy of consideration by some of our American manufacturers and railroad managers:

The new roof lamp was shown in a model of a railway carriage, from which all other light was excluded; and the smallest type could be easily read in any part of the compartment by the light of one central lamp only. The flame is placed laterally beneath a reflector of iron, enameled white, and the glass under the flame is smaller than in many of the old-fashioned lamps, by which it is scarcely possible to read at all. Several hundreds of the new lamps are already in use on the Great Eastern and Great Northern railways, and both companies have given further orders for them; it having been found that their light is neither diminished nor rendered unsteady by even the most rapid traveling, that there is no overflow of oil into the glass, and that a lamp will burn for eighteen hours without attention. Taking the experience with the new lamps of the Great Northern Railway, as compared with the lamp used by the London & Northwestern, the performance of which was tested at the Society of Arts, it is found that the Silber lamp gives about four times the light at four-sevenths of the cost; and the quality of the light is shown by the fact that it will quickly produce photographic prints upon ordinary sensitive paper without the intervention of a lens. It, therefore, contains a large proportion of chemical rays, which testify to the completeness of the combustion by which it is afforded. The last improvement introduced by the inventor is to render the lamp capable of burning any oil, whether vegetable or mineral, light or heavy, without alteration in its arrangements.

The lamp is the invention of Mr. Silber, of Silber & Fleming, Wood street, E. C., London.

On the of Heat Combustion of Coal.*

BY SCHEURER KESTNER AND MEUNIER DOLLFUS.

[*Annales de Chimie et de Physique*, Vol. viii, p. 267, 1886.]

ABOUT the year 1870, the authors made experiments on the heat of combustion of coal, and drew attention to the circumstance that this cannot be calculated even approximately from its chemical composition. Dulong's formula, which makes allowance for the hydrogen, in the form of water, in coal, gives results too low; whilst if all the hydrogen is taken credit for, the results of calculation are sometimes below, and at others above those of experiment. In their previous experiments, the authors used the coal in the form of powder; in the present case, in small pieces, in which state the coal burns more easily in the calorimeter. The gases used (compounds of oxygen and nitrogen) to burn the coal were always carefully dried, and the cinders were weighed after combustion. The present results confirm those previously recorded.

The coals experimented upon were of the most various character, the carbon ranging from 96.66 to 76.87; the hydrogen from 5.1 to 1.35, and the oxygen, nitrogen and sulphur from 18.45 to 1.99 per cent. The authors give a complete table of the results of their experiments, and compare them with the heat of combustion according to Dulong's formula. The lowest result, 8,259 centigrade units (pure carbon being 8,080), was obtained from a coal having the largest proportion of carbon, 96.66; the lowest of hydrogen 1.35, and the lowest of oxygen, nitrogen and sulphur, 1.99; whilst the highest, 9,623, from one having 88.48 of carbon, 4.41 of hydrogen, and 7.11 of oxygen, nitrogen and sulphur. Only 9,193 units were obtained from a coal of the composition 89.96 carbon, 5.09 hydrogen, and 4.95 oxygen, nitrogen and sulphur, which, from its chemical analysis, would appear to be a superior coal to the previous one.

* Abstracts of Papers in Foreign Transactions and Periodicals. Minutes from Proceedings of the Institute of Civil Engineers.

Manufactures.

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THE ROGERS LOCOMOTIVE AND MACHINE WORKS.

(Continued from page 48.)

CHAPTER V.

THE ORGANIC DEVELOPMENT OF THE LOCOMOTIVE.

DURING the period of fifty years that has elapsed since Mr. Rogers first commenced to build locomotives in Paterson, not only has the machine as a whole been going through a process of evolution, as described in preceding chapters, but there has also been a development or adaptation of its various parts or organs, as they may be called, to the functions which they have to perform. A description of the different forms and methods of construction of these organs, which were adopted and in use at various times, will, therefore, become a sort of comparative anatomy of American locomotives. This may conveniently be divided into three parts—one relating to the boiler, another to the engines, and a third to the carriage or running-gear. These will be taken up in succession.

THE BOILER.

The boiler of the "Sandusky," the first engine built by Messrs. Rogers, Ketchum & Grosvenor, was substantially the same as that of the Stephenson engines, of what is known as the "Planet" class, that is, the top of the furnace was semi-cylindrical in form, and flush, or nearly flush, with the top of the barrel of the boiler. The horizontal section of the fire-box below the barrel of the boiler was square, or nearly so.

In 1837, Mr. Bury was made locomotive superintendent of the London & Birmingham Railway in England, which gave him an opportunity of adopting extensively on that line a class of engines, the original of which he introduced on the Liverpool & Manchester Railway in 1830. These were four-wheeled engines with inside cylinders, not unlike Stephenson's in their general plan, but the tops of the furnaces instead of being semi-cylindrical were hemispherical, and the horizontal section of the fire-box, below the waist of the boiler, was of a form approximating to the letter D, the flat part being in front. This form of fire-box was adopted in the fifth engine built at the Rogers Works, and it was in continuous use until 1857, and is shown in Figs. 14 to 22.

A large proportion of the early locomotives built in this country were built to burn wood. The Baltimore & Ohio Railroad was, perhaps, the only pioneer road that commenced by using coal for fuel, and even on that line many locomotives burned wood. As the weight of locomotives was increased and coal was substituted for wood, larger fire-boxes were required, and this led to the abandonment of the hemispherical-topped furnace, which was not well adapted to fire-boxes whose length was materially greater than their width, and the semi-cylindrical form which was first used, was substituted in its place. In these, the crown-sheets were usually stayed with crown-bars placed either lengthwise or crosswise on the top of the fire-box.

At first the cylindrical tops of the furnaces were made flush with the tops of the barrels of the boilers, but this form was succeeded by what is known as the "wagon-top" form of boiler, which was first used in the Rogers Works in 1850. The tops of the furnaces, in the boilers of this kind, were also semi-cylindrical, but they were made considerably higher than the barrels of the boilers, as shown in Figs. 23 to 26. The exact reason for first adopting this form of boiler is not known, but it had the advantage of giving more steam room, and allowed the use of more tubes and consequently more heating surface, than could be used in a flush-topped boiler. The wagon-top also gives more room for workmen on the inside of the boiler, over the crown sheets, and it thus facilitates construction and repairs. Mr. Hudson was always a strong advocate of this form, and he gave especial attention to staying it, as is shown in Figs. 27, 28 and 29, in which the stays and braces are shown.

Fig. 27.

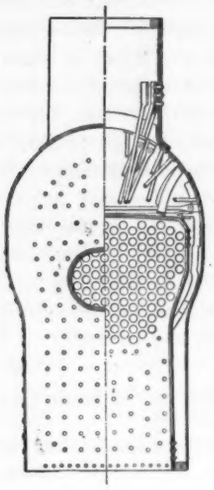
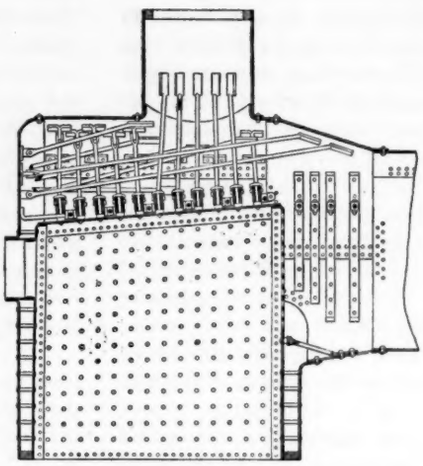


Fig. 28.



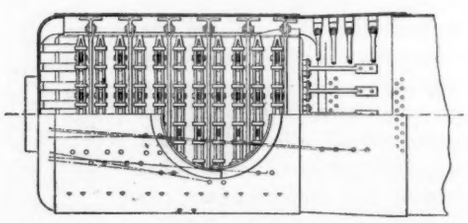


Fig. 29.

For burning anthracite coal, it was found that very long fire-boxes were required. In 1860, the form shown in Figs. 30 and 31 was built at the Rogers Works from the design of Mr. Millholland, of the Philadelphia & Reading Railroad. The top of this furnace sloped downward from the barrel of the boiler, and the crown-sheet was stayed with screw-stays, excepting for a short distance behind the tube plate. Water grates were used in this fire-box, and are shown in the engraving.

In 1861, some fire-boxes with long combustion-chambers and a water bridge, as shown in Fig. 32, were constructed for the New Jersey Railroad & Transportation Company.

In 1862, a fire-box with the water leg A, Figs. 33 and

34, was made for the Chicago, Burlington & Quincy Railroad.

The brick arch, Figs. 35 and 36, was used in 1865.

In 1871, some engines were built for the Cumberland Valley Railroad, with the Buchanan fire-box, shown by Figs. 37 and 38.

The form of the Belpaire fire-box, shown by Figs. 39 and 40, was applied to locomotives for the Matanzas Railroad of Cuba, in 1874.

The Belpaire fire-box has been extensively used on the Continent of Europe, and within the past few years has been regarded with much favor by some of the leading master mechanics in this country, and it has been adopted on a number of railroads here.

The fire-box represented by Figs. 27, 28 and 29 is, however, the one which has been most commonly used for engines built at the Rogers Works. It has stood the test of long experience, and is still regarded with much favor by engineers and master mechanics.

tinually expanded and contracted, which caused them to leak. With a steam-gauge, however, a fireman had always a guide before him to indicate just what the steam pressure was, and could control his fire accordingly, and, therefore, was not obliged to open the furnace-door so often to regulate the steam pressure.

While the frequent expansion and contraction of the tubes probably caused them to leak, yet there can be no doubt that the methods of fastening them which were at first used were much less efficient than those which have since been adopted.

The manner of fastening tubes in 1837 is shown in Figs. 45, 46 and 47. The tube was inserted into the hole in the tube-plate, and a tapered mandrel, shown by Fig. 46, was driven into the end of the tube, so as to expand it to the full size of the hole in the plate. The mandrel was flattened on five sides, as shown in the end view, Fig. 47. After each blow on the end of the mandrel it was turned slightly so as to expand the tube equally all around. The end of the tube was then turned over, as shown in Fig. 45, which represents a longitudinal

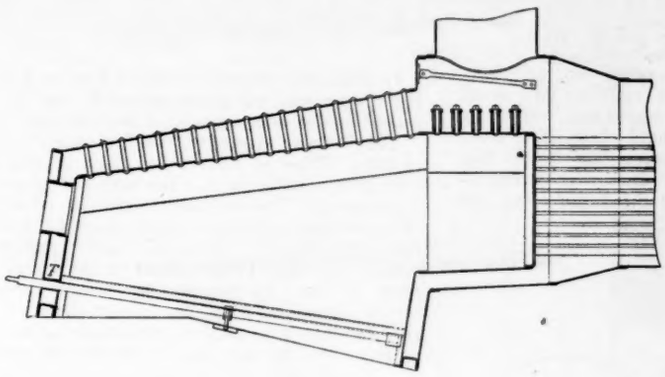


Fig. 30.

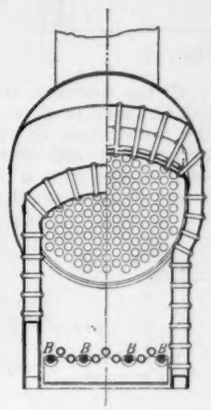


Fig. 31.

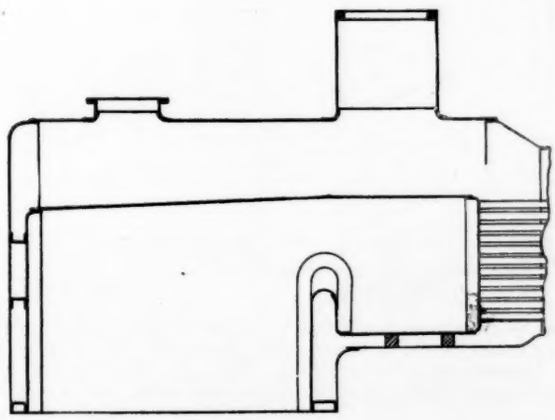


Fig. 32.

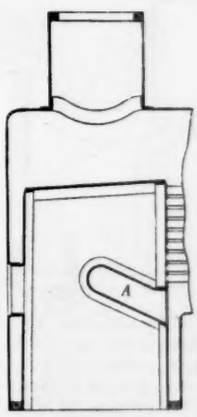


Fig. 33.

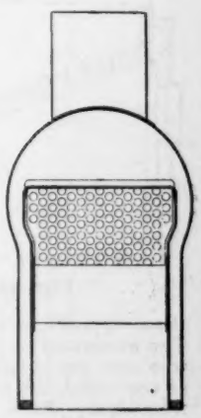


Fig. 34.

The form of brick arch shown in Figs. 41 and 42 was used in 1881. In this it will be seen that the fire-brick is supported on bent water tubes, which are attached at one end to the crown-sheet, and at the other to the front plate of the fire-box. Another form of brick arch supported on water-tubes, is shown in Figs. 43 and 44. This was used in 1885.

TUBES.

Very soon after coal was substituted for wood as fuel in locomotives, the use of copper and brass tubes was abandoned in this country, and iron tubes were used instead. At first there was a great deal of trouble in keeping these tubes from leaking. This was especially the case before steam gauges were generally used. Without these instruments it was impossible to tell what the steam pressure was, until the safety-valves commenced blowing off. They were, therefore, the principal guides by which the fireman was governed, that is, he would "fire" until "she commenced blowing off," and then he would open the furnace-door wide to cool the fire. The result was that the tubes were thus exposed to alternate currents of cold and hot air, and were thus con-

section of it. Probably some form of caulking tool was used for this purpose. A wrought-iron thimble, *T*, was then driven into the end of the tube.

In 1840, the form of caulking tool shown in Figs. 48 and 49 was adopted. This was inserted in the end of the tube with the notch *A* bearing against the edge, which was then turned over by driving the tool against it with a hammer.

As already stated, thirty or forty years ago, a great deal of trouble was experienced on locomotive engines with leaky flues. It was a constant source of annoyance, and every few days some one had to go into the furnace to hammer or caulk up the ends of the flues and thimbles (the flues at that time were either copper or brass, and the thimbles were of wrought-iron).

In 1850, Mr. Hudson, then master mechanic of the Attica & Buffalo Railroad, conceived the idea that if cast-iron thimbles were substituted for wrought-iron it would remedy this standing difficulty. Acting on this idea he proceeded to verify it— first, by taking a thimble of each kind, wrought and cast-iron, turning them accurately to a gauge, then heating them red hot, measuring them, and noting the expansion of each; afterward cooling them in water and again measuring

them. This process of heating, cooling and measuring was repeated twelve times, when the wrought thimble was found to be appreciably smaller in size than at first, and the cast-iron thimble larger. It was noticed that the former thimbles expanded more than the latter when red hot; this was anticipated.

To carry this idea into practice, a locomotive with leaky

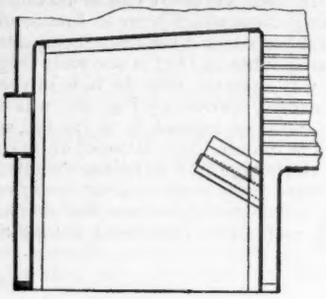


Fig. 35.

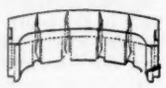


Fig. 36.

flues was taken; all the thimbles were taken out, the flues carefully expanded, and new thimbles put in. One-half or all on one side of the center line of the flue-sheet, vertically were of wrought-iron, and the other half were all of cast-iron. At the end of the first trip, when the boiler was cooling down, it was found that all the flues with wrought-iron thimbles were leaking, whereas, at the same time, all

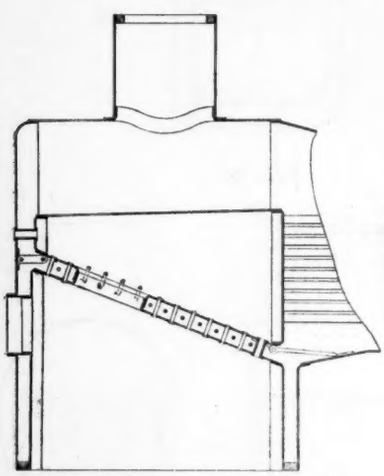


Fig. 37.

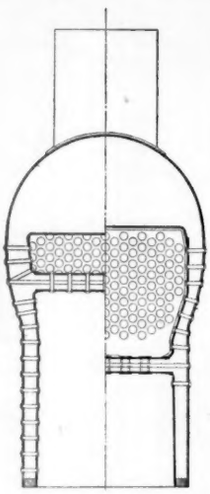


Fig. 38.

those opposite to them with cast-iron thimbles were tight. The wrought-iron thimbles were then taken out and cast-iron ones put in their places, when all stopped leaking, and so continued, the engine doing duty without any more trouble from leaky flues. The attention of Thomas Rogers was called to the fact, and he began to use the cast-iron thimbles with a like result. Mr. Rogers called the attention of

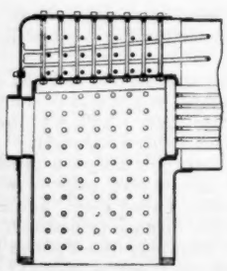


Fig. 39.

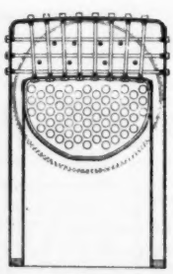


Fig. 40.

John Brandt, then in charge of the motive power of the Erie Railway, to the subject; he, also, immediately tried cast-iron thimbles, and found the result as stated above, and hence their use spread and became almost universal; few, except those who had experience in the matter at that time, can now realize how much annoyance and expense were saved by the change.

In 1861, tubes were fastened as shown in Fig. 50, that is, a copper end or thimble was brazed to the end of the tube, and a steel thimble was placed on the inside of it, so as to bring the copper between it and the tube-plate. The soft copper between the steel thimble and the plate, it was found, assisted materially in making and keeping the tubes tight.

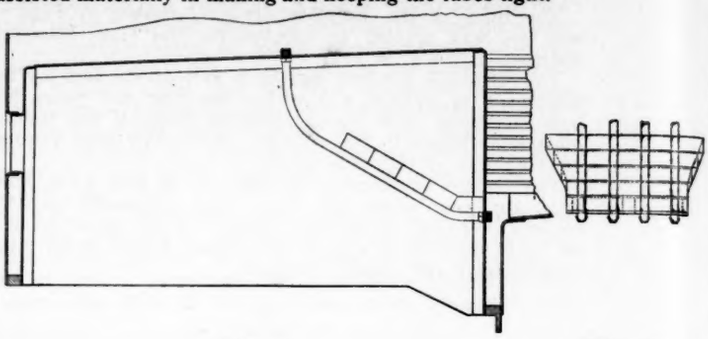


Fig. 41.

Fig. 42.

In 1862, the method shown in Fig. 51 was adopted. In this the copper end was dispensed with, and a copper thimble was placed on the end, outside of the tube, as shown.

The Prosser expander was first used at the Rogers Works in 1863. This is shown by Figs. 52 and 53. Fig. 52 is a side view with the end of the tube and plate shown in section at *A* and *A*. The expander consists of what may be called a plug composed of eight sector-shaped pieces, as shown in the end view, Fig. 53. These are held together by an open steel-spring ring *B*. In the center of the sectors there is a tapered hole *C*, Fig. 53 (shown by dotted lines in Fig. 52), into which a tapered plug, Fig. 54, is driven. The open spring-ring permits the sectors to separate when the tapered plug is driven into the opening. The sectors each have a shoulder

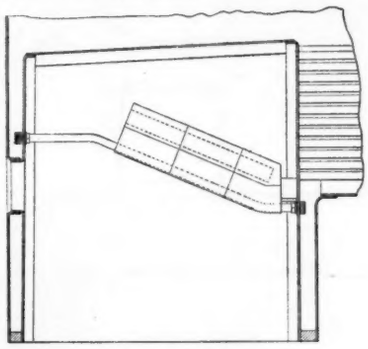


Fig. 43.

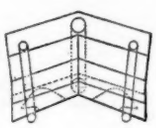
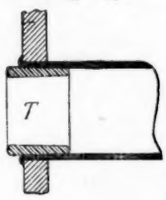


Fig. 44.

or projection at *S S*. These come just inside the tube-plate when the expander is inserted into the tube. By driving in the tapered plug or mandrel, Fig. 54, the sectors are forced apart, and expand the end of the tube. At the same

Fig. 45.



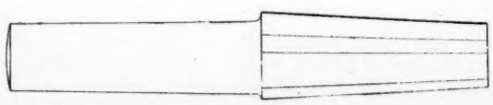


Fig. 46.

Fig. 47.

time the shoulders *S S* produce a ridge in the tube, inside of the plate, which helps to keep the joint tight.

In 1867, the Dudgeon expander, shown by Figs. 55 to 58, was introduced. This may be described as a hollow plug which has three rollers, *R R R*, Figs. 55 and 56, which are contained in cavities in the plug, in which they can revolve, and in which they can also move a short distance radially

Fig. 48.

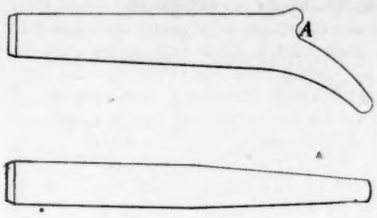


Fig. 49.

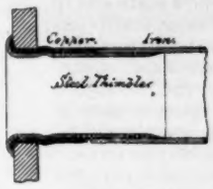


Fig. 50.

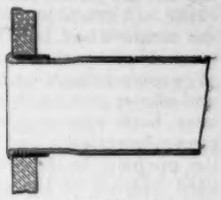


Fig. 51.

Fig. 54.

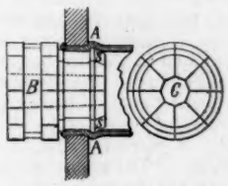


Fig. 52. Fig. 53.

Fig. 58. Fig. 57.

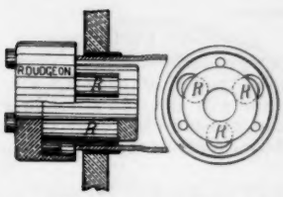


Fig. 55. Fig. 56.

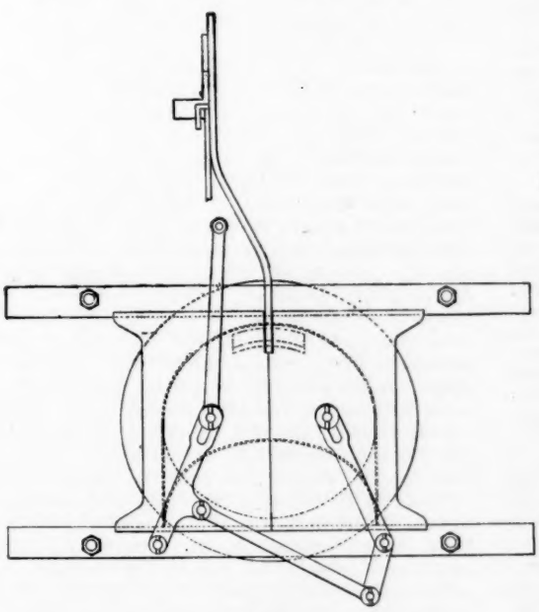


Fig. 59.

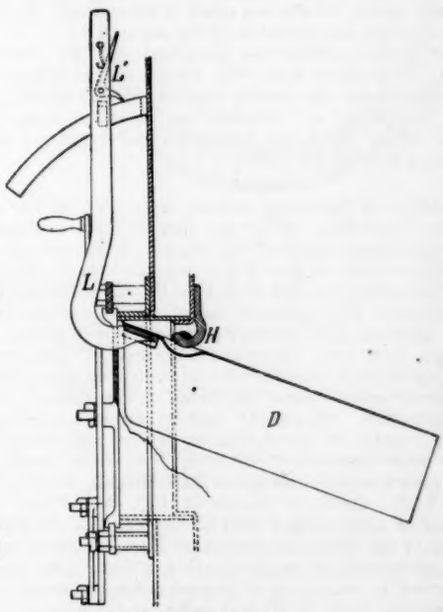


Fig. 60.

Fig. 61.

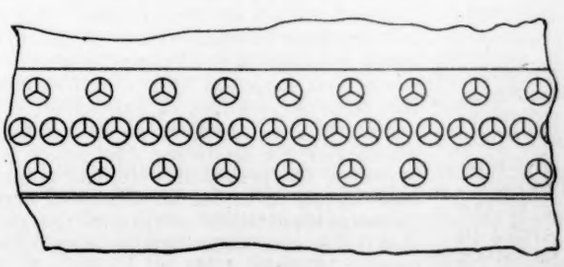


Fig. 26.

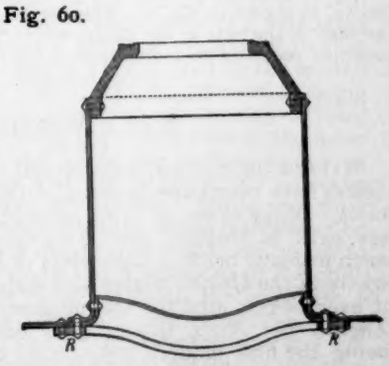


Fig. 63.

that is, from the center of the plug outward. When this expander is inserted in the end of a tube, a tapered mandrel, Fig. 57, is driven into the central opening, and it then bears against the rollers *R R*, and forces them outward against the tubes. A crank handle is then attached to the square end of the mandrel and it is turned around, which causes the rollers to revolve on their own axes. This causes the hollow plug to revolve around its axis. The two thus have a sort of sun-and-planet motion in relation to each other. As the rollers bear hard against the tube their effect is to elongate it circumferentially, and thus enlarge it so as to completely fill the opening in the tube plate. Usually, copper ferrules are used outside of the ends of the tubes. This method is one which is now generally employed at the Rogers Works for fastening tubes in their plates.

FURNACE-DOOR.

In 1865, Mr. Hudson used the furnace-door deflector illustrated by Figs 59 and 60. *D* is the deflector which is suspended from a hook *H*, attached to the fire-box over the furnace-door. A lever *L*, is fastened to the deflector, by which it is moved out of the way when coal is thrown into the fire. The position of the deflector is regulated by the lever, and a latch *L* at its upper end. A pair of sliding-doors are used in connection with the deflector. These are opened by a system of levers, which are clearly shown in the engravings. This was suggested by a fireman in England, who found that, by inserting a scoop shovel upside down in the furnace-door, he could prevent smoke.

BOILER SHELLS.

In making boilers with iron-plates, Mr. Hudson always took great pains to have the plates of such sizes and proportions that the "grain" or fibers of the iron around the barrel of the boiler would be in the direction to resist the greatest strain. This practice is still continued in the Rogers Works when iron plates are used.

In 1852, he adopted the method of making the horizontal seams of boilers shown by Figs. 61 and 62. This consisted of an ordinary single-riveted lap seam, with a covering strip or "welt" over the inside, which was made wide enough to take an extra row of rivets on each side of the main row. The outside rows were spaced double the distance apart of those in the main row. The welts not only serve to strengthen the seams, but they cover the inside caulking edges where corrosion and "grooving" or "channeling," as it is called, is most likely to occur. By being covered, these edges are protected from the action of the water.

DOMES.

The first method of fastening domes, as shown in the engraving of the "Sandusky," Fig. 12, was to rivet a circular casting, having a flange top and bottom, to the barrel of the boiler. The upper part of the dome was also made of cast-iron and was bolted to the top flange of the circular casting. A similar plan was also adopted when the domes were attached to the tops of the hemispherical-shaped furnaces, as shown in Figs. 12 to 22. Even after the use of the hemispherical-shaped furnace was abandoned, cast-iron domes were still used, and, in some cases, the bases of the domes were made of wrought-iron. When the size of engines and their domes was increased so much that is became impracticable and unsafe to make them of cast-iron, they were made of wrought-iron plates, with a flange at the bottom, which was riveted to the boiler shell, as shown in Fig. 30. Later, the boiler shell was flanged upward around the edge of the opening at the base of the dome, as shown in Figs. 26 and 27, in order to give additional strength at this point. The dome was then attached to the boiler with two rows of rivets. In 1880, a reinforcing ring, *R R*, was added at the base of the dome, as shown in Fig. 63. This serves to strengthen the boiler shell at the base of the dome, where it is weakened by the opening required to give access to the inside of the boiler.

(To be continued).

Brick Pavements.

WITHIN the past few years several towns in the Western States have been experimenting with street pavements of brick. Many miles of brick pavement, it is needless to say, exist in Holland, and, if we are not mistaken, there are remains of brick in the streets of Nantucket; but elsewhere in the United States this material has been rarely, if ever before, used for the purpose. According to the *Engineering News*, Bloomington deserves the credit of being the first modern town in the country to introduce brick paving on an extensive scale. The town is situated in the clay region, and bricks are cheap there, as well as good; and, by careful selection of material, it has been found possible to produce bricks so tough and hard that in Bloomington, where seven miles of streets are now laid with them, they have been found, after ten years' experience, durable, as well as cheap and convenient. In Amsterdam, where, although canals intersect the city in all directions, a good deal of traffic is carried on by means of horses and wagons, the pavements of small, whitish bricks show little sign of wear; and, partly on account of their porosity, and partly from the numerous joints which exist between them, they are in wet weather much dryer and pleasanter to walk over than stone, or even asphalt. In the Illinois towns, the streets are prepared for paving by forming natural surface into the proper profile; on this is then laid four inches of coarse sand or cinders, evenly spread, cinders being preferred on account of the better drainage which they afford, and the whole is covered with bricks laid flat, with joints as close as possible, and accurately formed to the desired profile. Fine sand is then spread over the surface, and worked well into the joints with a broom, and, after laying an inch more of sand over it, the top course, consisting of brickson edge, is set as closely as possible, and the joints of this also well filled with sand. The multiplicity of joints makes the pavement easy and safe for horses to travel over, and the whole cost is only from $1.40 to $1.80 per square yard.—*American Architect.*

[About ten years ago, Ross Winans, of Baltimore, laid the block adjoining his house in that city with a brick pavement, but we have no knowledge of the success of the experiment. Perhaps some reader in that city can give a report of the results.—EDITOR RAILROAD AND ENGINEERING JOURNAL.]

Pressure and Composition of Natural Gas.

IN a paper on this subject, read before the Engineers' Club, of Philadelphia, Dr. H. M. Chance, the author, says: "We have no records of the gas pressure first shown by the largest wells. The recorded pressures have nearly all been observed after the gas had been blowing off for some weeks, or months, or even years; and the pressure then shown by a gauge is evidently no measure of the pressure under which the gas exists in the rock, for the gas soon becomes exhausted from the immediate vicinity of the well, which then draws its supply from a considerable distance, and perhaps, through bands of rock of such texture (and perhaps, even through the clay filling of crevices) that the pressure shown at the well may be only a fraction of the actual pressure. Hence, while recorded pressures range from about 600 down to 200 pounds per square inch, we have every reason to believe that the actual pressures are, perhaps, from 500 to 1,000 pounds per square inch, or even, in some cases, much greater, but must still be less than the maximum as limited by depth. I have shown that this maximum is very much less than the pressure necessary to effect liquefaction, and we must abandon the supposition that the gas exists as a liquid.

"One of the most interesting phenomena recently observed in natural gas is its variability. The analysis of Prof. Sadler,* made some nine years ago, told us that gas from wells located in districts not connected with each other was similar in composition, but that the percentages of the different gases present varied widely. We were, however, not prepared for the discovery that gas from wells in the same "pool," and that from the same well, was subject to daily and even hourly variations in composition. When it was found that the calorific value of the fuel was subject to change, from time to time, as shown by variations in temperature of the furnaces, and in the steam pressure of boilers under which it was burnt, this was at first supposed to be due to differences in pressure, that is, in the quantity of gas delivered to the burners in the fire-box. Automatic pressure-regulators were introduced, and the producing companies perfected a system by which the pressures were maintained at a nearly constant figure, yet the same variations were observed. The chemists then began to examine the gas and some found that it was extremely variable in composition."

* Report L, Pennsylvania Geological Survey.

New Inventions.

The Whitney Contracting Chill for Casting Car-Wheels.

It is a well-known fact that in casting a railroad car-wheel, that part of the mould which forms the tread and flange of this wheel consists of an iron ring. It is called technically "the chill" or chill mold, because it suddenly cools or chills the molten iron used to cast the wheel, and thus produces a hard wearing surface of white iron on the tread. This "chill" heretofore has been simply a cast-iron ring of suitable thickness, turned out on its inner surface to the shape of the tread and flange of the wheel. Recently, however, what appears to be an improvement on its construction has been made by the well-known firm of A. Whitney & Sons, of Philadelphia. The improvement was first suggested many years ago by their Superintendent, Mr. L. R. Faught, the main idea at first being to prevent the disintegrating of the inner surface of the chill by sawing its face into many sections. A wheel cast in such a chill was part of their exhibit at the Centennial Exhibition in 1876. This led to many experiments with different forms of chills, both in their own shops and in the shops of the Pennsylvania Railroad Company at Altoona, under the superintendence of Mr. J. N. Barr, who at last obtained satisfactory results, and secured Letters Patent for his improvements. During 1885 Messrs. Whitney & Sons resumed their experiments, and, after very careful researches into the causes of previous failures, at last perfected their present device that their senior partner, Mr. John R. Whitney, has covered by several Letters Patent. The principles and construction of the chill known as the Whitney contracting chill, are so fully and clearly set forth in the patent specifications that we cannot do better than to quote directly from them, as follows:

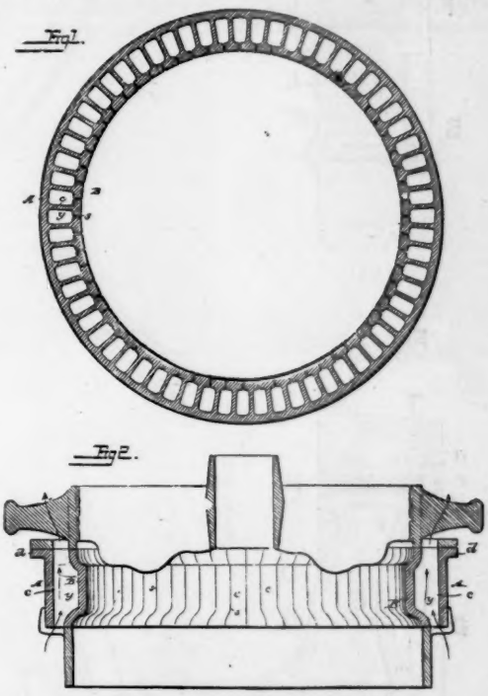
Ordinary car-wheel chills as heretofore made have consisted of solid rings of metal of about one inch and a half in thickness, and sometime more, and provided upon opposite sides with trunnions or handles. At other times, the chills have consisted of rings to which are bolted an inner facing or lining composed of separate pieces in close proximity. In other cases, the chill has consisted of a hollow ring with radial and vertical sections, which are made to expand and contract by alternate currents of steam and water through the hollow ring.

In the ordinary chills above named, the parts constituting the chilling-surface are of different thicknesses at different points in the circumference, and, owing to this and other features of the construction, the density of the metal varies at different points of the chilling-surface. Thus in a chill an inch and a half in thickness, the central portion is always much more open than the outer edges, and this inequality of texture is increased at intervals wherever there are projections, such as are formed by the trunnions and lugs. As a consequence, when the molten metal is poured into the mold, the chill does not expand equally at all points, and so remains in contact with the wheel longer at some points than at others, and thus produces a deeper chill wherever the contact is most prolonged. This effect is increased if the flask is out of level or the chill is unequally exposed to currents of air, etc. This unequal and irregular expansion of the chill is very apt to result in permanently altering its original shape, so that the wheels produced in it after a time become more or less out of round. As the inner surface of the ring is first heated and tends to expand before the outer portion can yield, the inner surface also soon becomes disintegrated and loses its original smoothness of finish.

Another difficulty resulting from the employment of chills of the ordinary construction ensues from the fact that if the molten metal is of a soft, fluid, low-chilling character it retains its heat much longer than when harder and chilling well. It thus expands the chill to a much larger size before the inclosed wheel becomes solid, and, as a consequence, wheels made from metals of different tempers, even if cast in chills of the same diameter, when cold, will be found to vary in their circumference.

All these difficulties are overcome, partly by the use of a chill of a particular form and partly by constructing the chill, whatever may be its form, so that all parts of the chilling-surface shall be of the same or nearly the same density, for the inventor has discovered that when the chilling-surface is of uniform or nearly uniform density the chill produced is more likely to be of uniform depth, and this discovery has enabled him to secure uniform results by a proper construction of the chill.

One means of making the chill so as to secure the uniform or nearly uniform density of the chilling-surface consists in constructing it of parts substantially uniform and not exceeding one inch in thickness, and preferably very much less, so that when cast there will be no undue strains, tending to condense some parts more than others. Thus, instead of making the chill in the form of a ring of one inch and a half or more in thickness, and with projections at some portion, it is constructed with two rings, A B, Fig. 1, each of about five-eighths or three-fourths of an inch in thickness, connected by webs, the inner ring, B, being of uniform thickness throughout its entire extent, while the webs *c*, which connect the inner to the outer ring, are no thicker than the inner ring. This uniformity in the thickness of the rings and webs insures a practical uniformity of density in the chilling-



THE WHITNEY CONTRACTING CHILL.

surface of the ring B. The outer ring A, is preferably made of the same thickness and entirely without trunnions or lugs, so that when the chill is heated all the parts will expand simultaneously and regularly.

To increase the efficiency of the inner ring B, it is separated into sections by narrow slots or kerfs *s*, extending radially into the openings *y* between the webs *c*, so that each section is free to expand when heated by the molten metal of the inclosed wheel without its surface being compressed, while the expansion of all the sections and their supporting-webs causes the contraction of the inner diameter of the chill and keeps the chilling-surface in close and equal contact with the wheel at all points as long as the chilling effects are needed. While the inner ring is thus kept in contact with the wheel the outer ring can be maintained in a nearly cool condition, so as to maintain the general shape and dimensions of the chill, by the natural passage of air through the openings *y* across the narrow webs *c*, the chill projecting beyond the cope and drag, so that the air can flow freely to and upward through and from said openings outside of the cope and drag.

Fig. 1

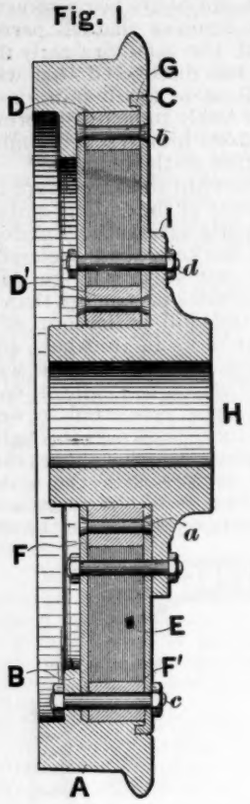


Fig. 2

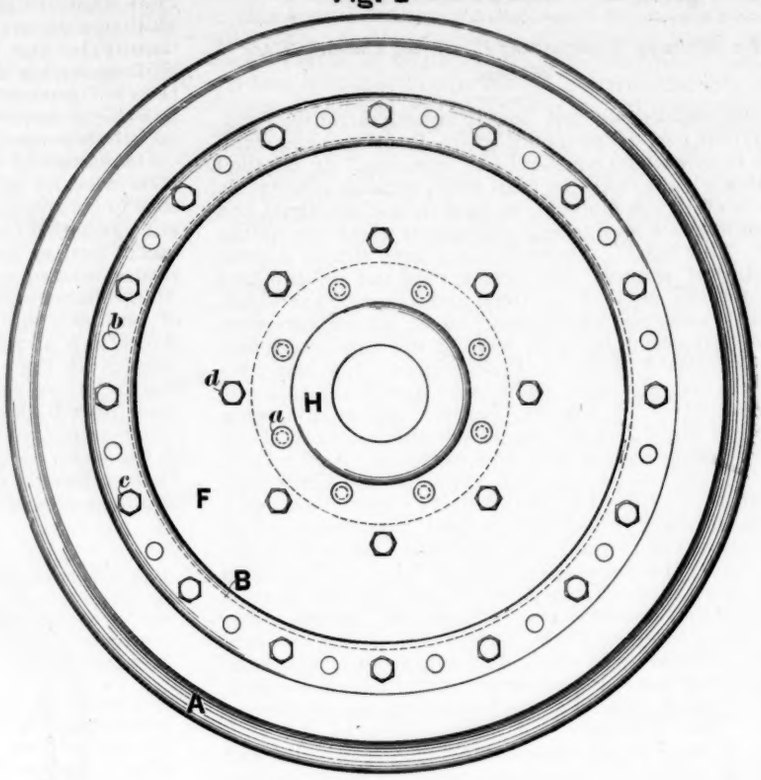


Fig. 3

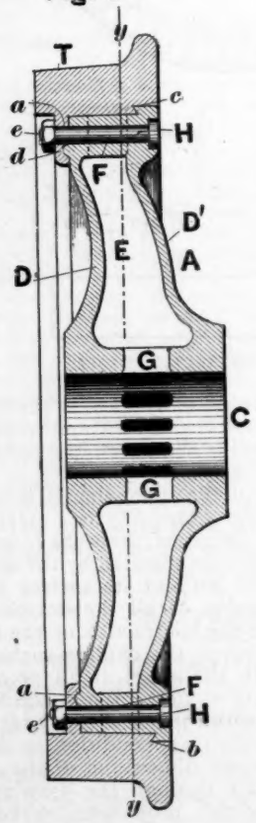
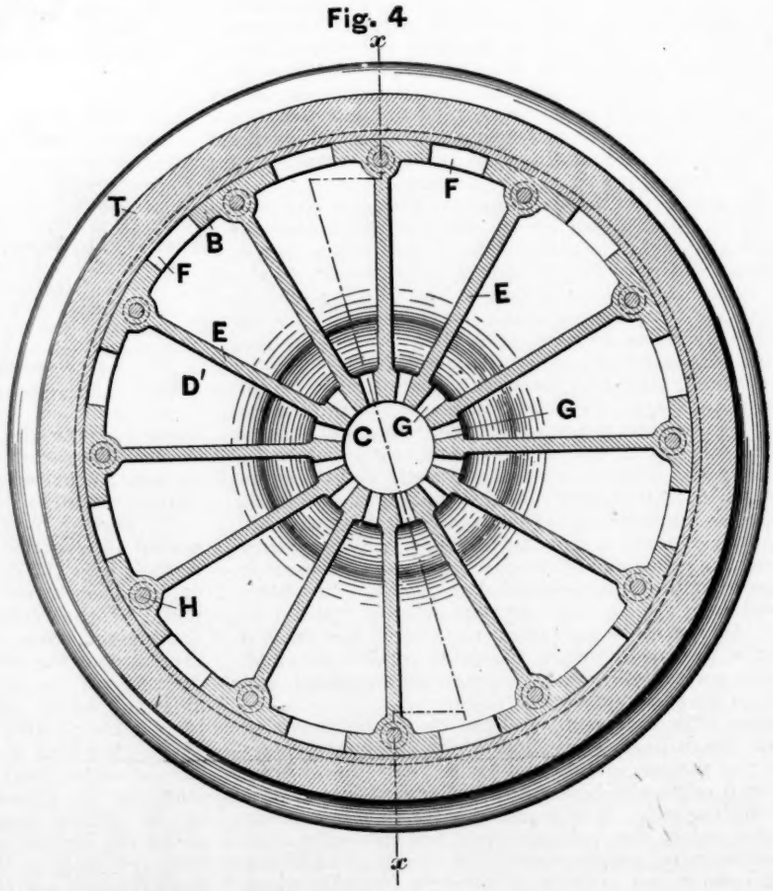


Fig. 4



ALLEN'S IMPROVED CAR-WHEELS.

Heretofore, when the inner face of the chill has been divided by radial slots, the latter have been made by means of saws or other thin cutting-tools. This involved great expense of tools and labor, and required that the sections should be comparatively thin at the points where thus cut, but, being thinner at these points than at others, produced a chilling-surface of varying thickness. The inventor, however, has discovered that the chill may be made complete with the slits between the sections by arranging thin sheets of asbestus in the mold, so as to separate the metal in the process of casting, the asbestus forming cores much thinner than the smallest kerf that can be cut by saws or other tools available for such purposes, or that can be made by strips of iron or other materials used as cores. By this means, he is enabled to separate the sections by spaces not exexceeding one one-hundredth part of an inch in width if required, thus allowing room for the requisite expansion of the sections and consequent contraction of the chill, and yet preventing the irregularities in the casting otherwise resulting.

When the molten metal is brought in contact with the *ordinary* chill, it is found that it begins to heat the same and expand it; but as soon as the metal solidifies it also itself expands, so as to remain in contact with the chill, until the solidification of the surface is complete, after which it immediately begins to contract, while the chill itself, if constructed as usual, continues to expand. If the chill is constructed in the ordinary manner, a constantly-increasing separation between the wheel and the chill thus takes place. But in the construction of the chill above described the outer ring A, remains cold and does not expand; but the heating of the ring B and the webs *c* causes the expansion of these parts, and the sections of the ring are moved inward, thus maintaining the chilling-surface in contact with the metal until the latter has become thoroughly hardened and deeply chilled. The chill thus constructed may be used in connection with the sprinkling apparatus shown in Letters Patent No. 258,182, whereby the effects above described are much increased; but whether the sprinkling apparatus be used or the natural draft of the air alone be depended upon for keeping the outer ring of the chill at a low temperature, the effect is to produce wheels of substantially uniform circumference regardless of the temper of the metal, inasmuch as the variations in the length of time with which the metal is in contact with the chilling-surface can have no effect in changing the size of the outer ring, which serves as a fixed abutment, from which the sections of the ring may expand, and thus contract the inner diameter of the chill.

In order to permit the chill to be readily lifted, it is preferable to provide the outer ring with a flange, *d*, Fig. 2, which extends completely around the periphery, but which does not materially affect the density of the chilling-surface of the inner ring or section of the chill. This flange serves as a means of seizing the chill by the grapples when it has to be moved, and has the further advantage of permitting the chill to be easily rolled from place to place, which cannot be done when it is provided with trunnions.

These chills are so constructed that the heat of the molten metal causes them to contract, instead of expand. This contraction is simultaneous and uniform at all points of the chilling surface. They thus remain in constant and close contact with every part of the tread of the wheels until the full chilling effect required is produced. The depth of chill thus secured does not vary materially in the whole circumference of the wheels; the wheels are practically as round as turned steel or wrought-iron tires and chills that have been in almost daily use for six months are found to retain accurately their original shape and size. Messrs. Whitney & Sons are thus enabled to produce wheels which they claim are greatly superior to any made in the ordinary way, especially in the following important particulars, viz.: Accurate roundness; uniformity of size; increased depth of chill; uniformity in depth of chill; greater density and durability of chill; and hence, an increased mileage under similar circumstances.

In order to still further meet the growing demands of railway service for an increase of strength and durability in wheels, we are informed that they have also, during the last year, made very important changes in the form of many of their patterns, and in their mixture of irons. In May, 1885, they ceased entirely to use steel, and their mixture now consists of charcoal irons, carefully selected because of their superior strength and chilling properties. They will guarantee that wheels made of such materials, and by their improved process, will give 25 per cent. more mileage than any wheels made in the ordinary manner and used under the same conditions.

Allen's Improved Car-Wheels.

THE engravings herewith represent two forms of car-wheels which have been patented by Mr. Richard N. Allen, and have recently been brought out by the Allen Paper Car-Wheel Company.

Figs. 1 and 2 represent an improvement in the well-known paper car-wheel which is so extensively used in this country. Fig. 1 is a section and Fig. 2 an outside view of the wheel. The improvement consists in the introduction of two wrought-iron or steel rings D and D′, in connection with a compressed paper core or disk E, which form the body or "center," as it is technically called, of the wheel. The core is enclosed between two wrought-iron or steel plates F and F′, which are fastened together by rivets *b* and *a* which pass through the plates and metal rings D and D′.

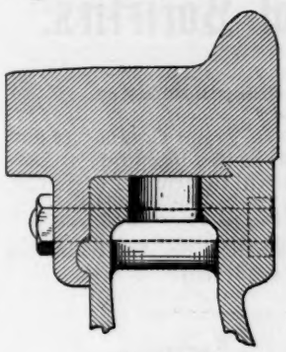


Fig. 5.

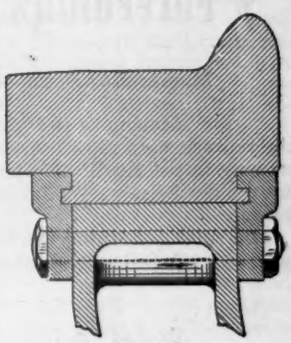


Fig. 6.

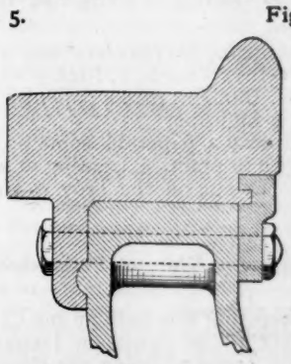


Fig. 7.

H is a cast-iron hub with a flange, I, on the inside, large enough to overlap the plate F′ and the ring D′. The latter and the hub are accurately bored and turned, and after the core E, plates F and F′ and the rings D and D′ are all fastened together by the rivets, the wheel center is forced on the hub and bolted to it by bolts *d*, which pass through the flange I, plates F F, and core E. The tire G′ is then fixed on the ring D and bolted to it by bolts *c*, which pass through the flange B, the plates F F′ and ring D.

The plate F′ is provided with a flange or tongue C which fits into a corresponding groove in the tire which helps to hold the latter in its place in case of a breakage.

The object of the rings D and D′ is to strengthen the wheel center, and also to form bearings for the tire and hub which will resist without injury the friction incident to forcing them on and off of the wheel center. With these rings either the tire or the hub, or both, may be removed as many times as may be necessary, and their peripheries

or bearings will still remain in good condition to receive new tires or hubs.

Mr. Allen has also patented a steel-tired wheel shown by Figs. 3 and 4, the center of which is made of cast-iron or steel. Fig. 3 is a section on line $x\,x$ of Fig. 4 or on the axis of the wheel, and Fig. 4 a section on the line $y\,y$, of Fig. 3.

The wheel center consists of a casting composed of two curved plates D and D′ united by radial webs or ribs E E, cast in the form of spokes. The spaces between the plates and the radial webs are cored out in a manner which will be obvious to any practical person.

The tire may be fastened on the wheel in any practicable way, as shown in Fig. 3 and on an enlarged scale by Fig. 5, or as shown in Figs. 6 and 7. Any of these methods will hold the tire to the wheel in case the tire breaks. With reference to cast-iron centers, it may be said that if they are safe for locomotive wheels of double the diameter and carrying twice the loads that car-wheels must bear, they surely should be safe under cars, if the tires are properly secured, so as to guard against accident in case of their breakage.

Both of the kinds of wheels illustrated above are manufactured by the Allen Paper Car-Wheel Company, of 239 Broadway, New York.

Proceedings of Societies.

Master Car-Builders' Brake Committee.

A joint meeting of the M. C. B. Brake Committee and the representatives of brake companies intending to participate in the April, 1887, tests, will be held at Pittsburgh, at 10 o'clock A. M., Wednesday, Feb. 9, at the Hotel Anderson.

The rules governing the tests will be decided on at this meeting. A full attendance is requested.

Boston Society of Civil Engineers.

A regular meeting of this Society was held in Boston, January 19, Vice-President L. F. Rice in the chair.

Mr. George W. Blodgett read a paper on the Steam Engine and Electric Lighting.

Mr. L. F. Rice read a paper on some problems in construction met with in practice, treating at some length on the Green River Bridge on the Troy & Greenfield Railroad.

Engineers' Club, of Philadelphia.

THE annual meeting was held at the Club House, No. 1122 Girard street, Philadelphia, on January 8th. President Washington Jones occupied the chair; 40 members were present.

The retiring President, Mr. Washington Jones, read the annual address. In it he gave a brief account of the most prominent engineering works projected, in progress and completed, abroad and in the United States. The importance of railroads to the people was dwelt upon; their bridges, tunnels, locomotives, etc., and the miles of track laid during 1886, were referred to. Street railroads, and the manner of moving their cars, elevated railroads and subway roads were compared and their qualities noted. New water works, especially those projected for the City of Philadelphia were noted, and extracts from Mr. Rudolph Herring's report on his surveys of water sheds, forming sources of supply other than that of the Schuylkill River, were quoted; also a description of the intercepting sewer (furnished by the courtesy of the Chief Engineer of the City of Philadelphia), intended to carry the sewage of Manayunk and discharge it below the pool at Fairmount. The quantities of minerals mined in the United States during several past years were noted and allusion was made to the Bartholdi Statue of Liberty. The concluding portion of the address was devoted to remarks upon the satisfactory condition of the Club, the convenience of its quarters and location, and the desirability of an increased number of papers upon professional matters.

The Secretary and Treasurer presented his annual report, showing total receipts of $4,144; expenses were $3,779, leaving a balance of $365. Besides its library and furniture the Club has assets amounting to $1,018. At the close of 1886, the Club had 3 honorary, 5 corresponding, 451 active and 9 associate members; a net increase of 28 active members.

The tellers reported the following officers elected for the ensuing year: President, Thomas M. Cleeman; Vice-President, Joseph M. Wilson; Secretary and Treasurer, Howard Murphy; Directors, John T. Boyd, C. W. Buchholz, Frederick Graff, Washington Jones and M. R. Mucklé, Jr.

President-elect Cleeman then made a brief and appropriate address.

After routine business had been disposed of, Mr. Henry R. Cornelius read a paper relating to the two large centrifugal pumps at Mare Island Navy Yard, California, built by the Southwark Foundry & Machine Company.

The pumps, the dimensions of which are 42-inch discharge pipes and 66-inch runners, are each driven direct by a vertical engine 28 inches diameter and 24 inches stroke, and were designed to remove the water from a dock 529 feet long, 122 feet wide and 36 feet deep, with a capacity of 9,000,000 gallons.

After being erected on foundations prepared by the Government, a test trial was made by a Naval Board, the following being extracts from their report:

"At the final trial of the two pumps together, the water was admitted to the 23d altar, the dock containing 7,317,779 gallons, being 7 feet above the center of the pumps. * *

"During a pumping period of 55 minutes the dock had been emptied from the 23d to 2 inches above the 6th altar, containing 6,210,698 gallons, an average throughout of 112,922 gallons per minute. At one time, when the revolutions were increased to 160 per minute, the discharge was 137,797 gallons per minute. This is almost a river, and is hardly conceivable.

"The engines worked noiselessly and without shock or labor. At no time during the trial was the throttle-valve open more than ⅜ inch.

"The indicator cards taken at various intervals gave 796 horse-power, and the revolutions did not exceed 160 at any time, though it was estimated that 900 horse-power and 210 revolutions would be necessary to attain the requisite delivery."

The reading of other papers was deferred to the next meeting, and the Club adjourned.

Engineers' Society of Western Pennsylvania.

This Society held its seventh annual meeting in Pittsburgh, on the evening of January 18. It was first organized seven years ago with 32 members; there are now 306 on the roll.

The President made his annual address, which was a general review of the work done by the Society during its seven years of existence, following by a brief outline of the scientific history of the year just closed.

The Treasurer's report showed that the total receipts for the year were $1,154, and the expenditures $981. There is now $306 in the treasury, and the library fund amounts to $120. The Library Committee reported the addition of a new book-case filled with valuable technical works.

A minute was adopted on the death of Thomas M. Carnegie, an active member of the Society.

The following officers were elected for the ensuing year: President, Alexander Dempster; First Vice-President, J. A. Brashear; Second Vice-President, M. L. Becker; Directors, A. E. Hunt, William Miller; Secretary, S. M. Wickersham; Treasurer, A. E. Frost. The meeting then adourned.

Engineers' Club, of St. Louis.

This Club met in St. Louis, January 19, President Polter in the chair; 26 members and 6 visitors present. A number of applications for membership were received.

The Secretary reported having prepared an engrossed copy of the memoir on C. Shaler Smith as directed at the last meeting.

The special order of the day, a paper by H. S. Pritchett on Mexican Longitude Determinations, was then taken up. The Club then adjourned to a room specially prepared for the occasion. By the aid of the magic lantern the paper was fully illustrated. A complete description of the apparatus used, the method of making the observations and of computing the results were explained and the results were compared with those previously obtained by other methods. The author showed a number of views of Mexican scenery and points of interest, with some remarks on peculiar features of the country and the characteristics of its people.

The Club then adjourned to visit the time department of Washington University.

PERSONALS.

Mr. J. F. Wallace has been appointed Chief Engineer of the Peoria Terminal Railroad at Peoria, Ill.

Mr. John T. McNeil has been appointed State Inspector of Coal Mines of Colorado for another term.

Mr. John B. Yates is Chief Engineer of the Zanesville, Mt. Vernon & Marion, a new line which is to run from Zanesville, O., to Marion.

Mr. Ferdinand Hall has been appointed Chief Engineer of the Louisville, New Albany & Chicago road, and will have his office in Chicago.

Mr. J. F. Hinckley has been appointed Chief Engineer of the St. Louis, Arkansas & Texas road, and will have his headquarters at Texarkana, Texas.

Capt. Francis V. Greene, United States Engineers, has resigned his commission to take the position of Vice-President of the Barber Asphalt Company, of New York and Washington.

Mr. C. Breckenridge, of Covington, Ky., has been engaged to make a preliminary survey for the projected Tennessee Midland road, from Knoxville, Tenn., through Nashville to Memphis.

Mr. J. B. Barnes has been appointed Superintendent of Motive Power, and M. M. Martin Superintendent of Car Department, for the Wabash, St. Louis & Pacific lines east of the Mississippi River.

Col. Charles E. Blunt, United States Engineeers, was placed on the retired list January 10, on account of age. Col. Blunt graduated from West Point, 1846, and has served in the army for 40 years.

Mr. George W. Cope, for two years past Secretary of the American Iron & Steel Association, has resigned that office, and accepted the position of Western editor of the *Iron Age*, with office in Chicago.

Professor Samuel P. Langley, of the Allegheny Observatory at Pittsburgh, has received from the Royal Society, London, England, the Rumford gold medal for "meritorous discoveries in light and heat."

Mr. W. W. Rich has been appointed Chief Engineer of the Minneapolis & Pacific, with office in Minneapolis, Minn. He retains his position as Chief Engineer of the Minneapolis, Sault Ste. Marie & Atlantic also.

Mr. W. H. Peddle, under the new organization of the Central Railroad of New Jersey, will be Engineer of the New Jersey Central and the New Jersey Southern divisions, and Mr. J. H. Thompson is Engineer of the Lehigh & Susquehanna Division.

Mr. I. C. Brewer, recently Division Engineer on the Lake Shore & Michigan Southern road, has resigned his position and gone to Chattanooga, Tenn. He will have charge of the construction of several branch lines for the East Tennessee, Virginia & Georgia road.

Prof. R. H. Richards, President of the American Institute of Mining Engineers, sailed from New York for Bermuda, early in January. Prof. Richards' health is much improved, but it is doubtful whether he will be able to attend the February meeting of the Institute.

Mr. Louis Caldwell is to have charge of the survey of the Louisville, Cloverport & Western, a new line projected to run along the south side of the Ohio River from Louisville to Henderson, Ky. Mr. Caldwell has been recently Superintendent of the Louisville & Portland Canal.

Mr. R. H. Elliott is Chief Engineer of the new Kansas City, Memphis & Birmingham road, succeeding Mr. John A. Grant, who goes to the Texas & Pacific as General Manager. Mr. Elliott has been for some time Assistant Chief Engineer of the Louisville, New Orleans & Texas road.

Mr. William G. Raoul retired from the position of President of the Central Railroad Company of Georgia at the annual meeting in January. He had been connected with the road for 15 years, serving successively as Roadmaster, Assistant Superintendent, Superintendent and Vice-President until 1883, when he was chosen President in place of the late William Wadley.

Mr. A. A. McLeod, who succeeds Mr. John E. Wootten as General Manager of the Philadelphia & Reading road, was for several years General Manager of the Elmira, Cortland & Northern road in New York. He went to the Reading road last year as Assistant to the President, and was made Acting General Manager when Mr. Wootten retired on account of ill health.

Gen. E. P. Alexander, who succeeds Mr. W. G. Raoul as President of the Central Railroad of Georgia, has had a somewhat varied experience. He is a graduate of West Point, and served several years in the United States Engineer Corps. During the war he served in the Confederate Army, and was for some time Chief of Artillery, under Gen. Lee. After the war he was successively General Superintendent of the Charlotte, Columbia & Augusta, General Manager of the Western Railroad of Alabama, President of the Georgia Railroad and First Vice-President of the Louisville & Nashville. He left the last-named road four years ago, and has since been chiefly employed as a consulting engineer.

Mr. Arthur M. Wellington has become editor and part proprietor of the *Engineering News*, of New York. Mr. Wellington is an engineer of experience, having served as Assistant Engineer on the New York, Pennsylvania & Ohio, Locating Engineer of the Mexican National; Assistant General Manager of the Mexican Central, in which capacity he located the Guadalajara Branch of that road, and in other important positions. For several years past he has been Associate Editor of the *Railroad Gazette*. Mr. Wellington is author of the "Economic Theory of the Location of Railroads," and of many contributions to engineering papers. He has been an active member of the American Society of Civil Engineers, and has contributed a number of papers to its proceedings.

Mr. John E. Wootten, for a number of years General Manager of the Philadelphia & Reading Railroad, has finally resigned that position, his health not having sufficiently improved to enable him to resume the duties of the position on Jan. 1, as he had expected to do. Mr. Wootten has been connected with the Reading road continuously for more than 41 years, having begun work in 1845 as foreman of the roadway shops at Pottstown. Two years later he was made foreman of the Palo Alto repair shops, and in 1854 he was transferred to the more important shops at Port Richmond. He remained in charge of these shops for ten years, and was then made Superintendent of the Mine Hill & Schuylkill Haven Branch. In 1866 he returned to the machinery department as its head, having been appointed Engineer of Machinery, and in 1871 the duties of Assistant Superintendent of the road were added to those of his former position. In 1873 he became General Superintendent of the road, and four years later was promoted to the position of General Manager. A few months ago he received leave of absence on account of impaired health.

Mr. Wootten is thoroughly familiar with the Reading road, having been connected with it for a longer period than any other person now prominent in the management. He is also well known to mechanical engineers as the inventor of the Wootten fire-box, the use of which has been increasing for several years past. He early recognized the necessity of increasing the grate area to meet the constant demands for increased power from the locomotive boiler, and his fire-box is the best known and most practical of the attempts so far made to put this principle into practice. Mr. Wootten's many friends will hear with regret of his present retirement from active work.

Notes and News.

Poughkeepsie Bridge.—The large caisson for Pier No. 5, has been launched and is now receiving the upper courses of timber.

German Enterprise in Mexico.—German manufacturers of agricultural machinery are said to be arranging for a united effort to introduce their machines into Mexico.

The Bridge Pier in the Mississippi, at St. Paul, erected by the Minnesota & Northwestern Railroad, the Secretary of War says, is an obstruction to navigation, and asks Congress to take action.

Ries Electric Railroad Manufacturing Company.—This company has been organized at Portland, Me., with $1,000,000 capital stock to build railroads and electric motors on the Ries system.

The Lehigh Valley Company is about to build a coal storage trestle in Chicago, which will be 100 × 886 feet. It will have a storage capacity of 25,000 tons, and arrangements for loading 30 cars at once.

The Dam across the Potomac at the Great Falls is nearly completed. The tunnel intended to carry the water supply of Washington from the dam is excavated for 18,538 feet, leaving 2,150 feet to be completed.

The Reese Safety Brake.—The automatic freight-brake invented by Alvan Reese, of Pittsburgh, is to be put on a number of cars on the Baltimore & Ohio road. The brake is made by the Reese Safety Brake Company, of Pittsburgh.

Compound Locomotives in England.—The London & Northwestern Company's experience with compound locomotives on the Webb system has been so favorable that it is now building 30 locomotives of that type, at its Crewe Works.

A "Hydro-Pneumatic Brake."—A brake thus described is to be manufactured by the Hydro-Pneumatic Car Brake Company, which has just been organized by William Susby, Jr., and others, at Newport, Ky., with $1,000,000 capital stock.

Cable Railroad in China.—A cable railroad has been built at Hong Kong, running from the city to the top of the Peak, a steep hill on which are situated a number of dwellings occupied by the European residents. The road is 4,800 feet long and rises 1,300 feet.

Ship-building in England.—Ship-building on the Tyne, in England, in 1886, shows a considerable reduction from 1885. Last year 67 vessels were launched, having a total tonnage of 82,800, against 106,000 in 1885. The average tonnage of the vessels launched last year was 1,236.

South Pass Jetties.—The report of the Secretary of War notes that, at the South Pass jetties of the Mississippi River, the channel has been maintained as required by law, and Capt. Eads has received the required payments of $150,000. The total cost of this improvement to date has been $5,300,000.

Trial of English Permanent Way.—A contemporary reports that the Pennsylvania Railroad Company will try a few miles of track laid in the English fashion, with rails of bull-head pattern, heavy cast-iron chains, and about 2,000 ties to the mile, or one-fourth less than are usually used in this country.

Washington Railroad Stations.—The Engineer Commissioners of the District of Columbia, in their annual report refer at some length to the railroad question, and urge the concentration of the railroad tracks entering the city of Washington. They also recommend the removal of the railroad tracks from existing streets.

Burlington Brake Test.—The Wells & French Co. is building at its shops in Chicago a train of 50 box cars for the Eames Vacuum Brake Company, to be used at the Burlington tests in April next. These cars are, of course, equipped with the Eames automatic freight brake; they are fitted with the Boston automatic coupler.

Cairo Bridge.—The engineers of the Illinois Central Railroad are now making the final location for the bridge over the Ohio River at Cairo, and work has been begun on the approach on the south side, which will include a trestle 3,000 ft. long. The bridge itself will be about a mile long and 52 feet above high water; the approaches will be about 1½ miles long.

Refrigerator Cars.—The New York, Lake Erie & Western Company has built 10 refrigerator cars, at its Susquehanna shops, which are to be run as express cars on passenger trains. These cars are 50 feet long, and are divided into three 16-feet compartments. They have passenger-car running gear, Miller platforms and couplers, and are fitted with the automatic brake.

Niagara Suspension Bridge.—Important improvements have been made this season in the Suspension Bridge over the Niagara River. These include the strengthening of the old anchors for the cables and the addition of new anchors. New steel towers have been erected in place of the old stone towers. The operation of transferring the cables to the new towers was successfully performed.

Union Switch and Signal Company.—This company has bought from the Pennsylvania Steel Compay the interlocking switch and signal department of its works, including the Cummings and other patents covering the system adopted by the Pennsylvania Steel Company. The business will be transferred to the new works of the Union Switch and Signal Company at Swissvale, near Pittsburgh.

A Russian Oil Pipe Line.—The United States Consul at Odessa, Russia, has notified the State Department that arrangements are to be made to build a pipe line to transport petroleum from Baku to Batoum. The line will be about 550 miles long, and its greatest elevation about 3,000 feet. It is proposed to use 7-inch pipe. The Consul thinks that American pipe and pump manufacturers will have an opportunity to secure contracts.

Liquid Fuel in Russia.—Some of the large factories in Odessa are now using as fuel in their boilers petroleum refuse, which is brought to Odessa by sailing vessels and is sold at a very low price. It is claimed that with the furnaces in use, a ton of this petroleum refuse will make as much steam as two tons of English coal. Arrangements are being made to carry the oil refuse in bulk from Novorossisk, the port of the Black Sea petroleum fields.

English Iron Production.—*The Engineer* estimates the pig-iron production of the United Kingdom for 1886 at 6,800,000 tons, against 7,250,657 tons in 1885; a reduction of 450,657 tons, or 6¼ per cent. The decrease in production has been continuous since 1882, when the total reached 8,498,000 tons. The reduction was not by any means uniform, the furnaces in Scotland and in the Cleveland district showing a small increase last year over 1885.

Railroads in Persia.—It is given out from St. Petersburg that Russian influence, which is very strong at Teheran, will be brought to bear to prevent the building of any railroads in Persia by English or American contractors. The Russian Government, it is said, is decided in its opinion that any important line to be built in Persia must connect with the Central Asian road which Russia is now building, and the Persian railroad administration must be controlled by Russian influences.

German Rails for English Colonies.—The Government of Victoria (Australia) has placed a contract for 50,000 tons of steel rails with the Krupp Works, at Essen. The deliveries are to extend over two years, and the price is said to be about $20 per ton, delivered on board ship. The bid of the Krupp Works was from $2.50 to $3 below the prices offered by English firms. Naturally, the English makers are much exercised in mind at so large an order from an English colony going to a German mill.

American System of Irrigation in Australia.—The Government of the Australian colony of Victoria has granted 50,000 acres of land to Chaffee Brothers, American capitalists, who are to colonize the land and improve it by irrigation. The land is near Mildura, on the Murray River, 11 miles above the mouth of the Darling. The conditions of the grant are that Chaffee Brothers are to spend $1,500,000 on irrigation works, and are to improve at least 47,000 acres of the tract within 20 years.

The Heating of Cars by Steam is tried on several railroads this winter. The Connecticut River Railroad has in use the Emerson system; the Boston & Albany has the Martin system as prepared by the Martin Anti-fire Car Heater Company, of Dunkirk, N. Y.; the Long Island Road is trying the Martin system on one train, and the Gold system on another. The Gold system has also been put in use recently on the Providence, Warren & Bristol Road, and on the cable road at Hoboken, N. J.

Blast Furnaces of the United States.—Statistics collected by the *American Manufacturer*, show that on January 1, 1887, there were 333 furnaces in blast, having a weekly capacity of 127,660 tons of pig-iron; against 273 in blast, with a capacity of 97,050 tons on January 1, 1886. Of the furnaces in blast this year, 66 use charcoal as fuel; 126, anthracite coal, and 140, bituminous coal or coke. The weekly capacity of the charcoal furnaces in blast is 11,895; of the anthracite, 53,633, and of the bituminous furnaces, 90,032 tons.

The Hoosac Tunnel.—The Troy & Greenfield Railroad, including the Hoosac Tunnel, has been sold by the State of Massachusetts to the Fitchburg Railroad Company. The State receives for the raad and tunnel $5,000,000 in bonds bearing 3 per cent. interest for five years, 3½ for five more and then 4 per cent., and will also receive $5,000,000 in stock of the company. The railroad and tunnel have cost the State (including interest paid) about $24,200,000. The price secured is probably the best that could be now obtained.

New Blast-Furnaces.—On Jan. 1, there were 22 new blast furnaces under construction. Of these, there were in the South 12, to have a productive capacity of 7,450 tons weekly; and the North 10, with a capacity of 7,800 tons weekly. Of the northern furnaces, three are at Troy, N.Y., the rest in Pennsylvania. Of the southern furnaces, one is in Kentucky, one in Tennessee and 10 in Alabama. The northern furnaces are generally larger, having an average capacity of 780 tons weekly, against 621 tons for the southern furnaces.

English Steamer for the Central American-New York Trade.—Robert Duncan & Co., Port Glasgow, Scotland, recently launched a steel screw steamer of 1,615 tons, intended for the fruit trade between Central American ports and New York. She is 236 ft. long, 35 ft. beam and 19 ft. depth of hold. The engines will be of the triple-expansion pattern, with cylinders 23 in., 35½ in. and 57 in. diameter, and 39 in. stroke. Steam will be supplied from two boilers, each 13 ft. 6 in. by 10 ft. 6 in., intended to carry a working pressure of 160 lbs.

Bridges at Minneapolis.—Plans have been prepared for three bridges over the Mississippi, at Minneapolis, Minn. One at Twentieth avenue will have four spans of 200 feet each, one at Franklin avenue, five spans of 200 feet each, and one at Lake street, six spans of 200 feet each. Work is in progress on a steel arch bridge at Hennepin avenue, which is to have two spans of 260 feet each. City Engineer Andrew Rinker is preparing plans for another bridge to cross the river at the falls; this will have one span of 540 feet, one of 200 feet and and three of 160 ft. each.

Lake Superior Iron Ore.—A good indication of the increase in the iron trade is found in the shipments of iron ore from the Lake Superior region. According to the Marquette *Mining Journal* these amounted last year to 3,541,996 tons, against 2,456,548 in 1885; an increase of 1,085,448 tons, or 44 per cent. Last year's shipments were the heaviest ever made, partly on account of increased demand, and partly because of the opening of mines on the new Gogebic Range. The total shipments of ore from the Lake Superior region up to the close of 1886 have been 29,774,099 tons.

The Union Bridge Company has its shops, both in Buffalo and Athens, Pa., fully employed. The work in progress includes the material for two notable structures, the bridge over the Hudson River, at Poughkeepsie, and the Hawkesbury River for New South Wales. A number of bridges for western and southwestern roads are also in progress, including one of 400 feet span over John Day's River, in Oregon, for the Oregon Railway & Navigation Company. This company is negotiating for the purchase of the rolling-mill property at Elmira, N. Y., and will, it is said, move its Athens shop to that place.

Ship Railroad at the Dalles of the Columbia River.—The project for a canal around the Dalles of the Columbia River, in Oregon, has been abandoned for the present, on account of the great expense involved. It is now proposed to build at the Dalles a ship railroad on the plan of Capt. Eads, by which steamboats can be taken from the water and transferred around the obstructions. It is thought that such a railroad can be built for $1,500.000, and an effort will be made to get an appropriation from Congress. At present the commerce of the river is impeded by the necessity of transferring all freight at the Dalles.

Russian Railroads.—The Russian Government has decided to begin no new railroad work in 1887, chiefly for financial reasons. Work will, however, be continued on the lines already sanctioned, of which some 750 miles remain to be completed. The most important lines now under construction are the Siberian Railroad, from Samara to Ufer, 440 miles; the Pskoff-Rjeff line, 255 miles; the Gomel-Briansk line, about 175 miles, and the Novorossisk-Tikhorelsk line, 170 miles. Several other lines have been urged to serve wheat-growing districts, but all are postponed for the present, the military lines receiving the preference.

Ohio Engines for Massachusetts.—The Prospect Engine and Machine Company in Cleveland, O., recently completed a pair of automatic engines, for the Lowell Carpet Company, in Lowell, Mass. These engines have cylinders 39 inches diameter and 40 inches stroke. The cranks are disks 72 inches diameter; the crank shaft is 20 inches diameter and 22 feet 10 inches long. The crank pins are 10⅜ inches diameter. The connecting rods are of the solid end type. The fly-wheel is 20 feet diameter and its face is 6 feet; it will carry three belts, two of 40 inches wide and one 36 inch. The engines will make 80 revolutions a minute.

Elevators for the New York Elevated Roads.—An association of property owners, known as the North Central Park Improvement Company, is making arrangements to put up a substantial building containing four passenger elevators in connection with the 116th street station of the Sixth avenue elevated road in New York. This building, when completed, will be leased to the Manhattan Railway Company at a nominal rental, that company to maintain and operate the elevators. The 116th street station is at the highest point on the road, and the great height of the stairways has been a serious drawback to property in the neighborhood.

East River Bridge.—The proposed bridge over the East River, at 60th street, New York, is to be pushed, and a bill, which has been prepared to authorize its construction, will soon be introduced in Congress. It is now proposed to start the eastern approach near Calvary Cemetery, west of Long Island City. The western approach is to form a Y, one arm extending to Fourth avenue and 42d street, the other to the Harlem Railroad track at 80th street. The bridge proper will be 155 feet above mean high tide, and is to have double railroad tracks, a carriage-way and foot-way. The total length of the proposed bridge and the approaches will be nearly 3½ miles. The design is for a cantilever bridge, the plans having been prepared by Mr. C. C. Schneider.

A Three-cylinder Locomotive.—The Dunmore Iron & Steel Company, at Dunmore, Pa., has a small locomotive in use switching in its yards which is of a novel pattern. It is thus described by the Superintendent of the works: "This little engine has three 8 × 12 in. steam cylinders, four 33-in. driving-wheels, two outside connecting and parallel rods, and one inside connecting rod. No balancing is needed in driving-wheels. The engine has six exhausts to a revolution, and the effect on the fire is good. It is claimed that by setting the cranks at an angle of 120 degrees the slip is reduced to a minimum. This engine makes 30 miles an hour on a 40 ft. grade easily, with a light load, and is considered a good machine by those who have run her. Its weight is about 12 tons."

Broken Axles and Rails in England.—*The Engineer* says: "Of the 238 axles which failed during the first nine months of 1886, on our lines, 147 were engine axles, viz.: 130 crank or driving, and 17 leading or trailing; 20 were tender axles, 2 were carriage axles, 63 were wagon axles, and 6 were salt-van axles; 29 wagons, including the salt-vans, belonged to owners other than the railway companies. Of the 130 crank or driving axles, 91 were made of iron and 39 of steel. The average mileage of 85 crank or driving axles made of iron was 233,057 miles, and of 39 crank or driving axles made of steel 223,933 miles. Of the 164 rails which broke, 79 were double-headed, 83 were single-headed, 1 was of the bridge pattern, and in one case the pattern was not stated; of the double-headed rails, 49 had been turned; 31 rails were made of iron and 133 of steel."

"Strong" Locomotive.—A second locomotive of the "Strong" pattern has been turned out of the Lehigh Valley shops at Wilkes-Barre, Pa. This locomotive has two fire-chambers, each consisting of a corrugated steel flue, both being joined at the forward end to single combustion chamber. From this chamber 309 flues, 1¾ inches diameter and 11 feet 5 inches long, extend to the smoke-box. The fire-chambers are each 42 inches diameter and 9 feet long. The total grate area is 62 square feet, and the heating surface is 1,848 square feet in all. The fuel is anthracite coal. The engine is intended for passenger service; has 20×24 inch cylinders, and six 62-inch driving-wheels coupled, 5 feet 7 inches from center to center, making the rigid wheel-base 11 feet 2 inches. There is a four-wheel truck under the cylinders, and a two-wheel truck back of the drivers and under the fire-chambers. This trailing truck is equalized with the drivers. The valve-gear is of the "Strong" pattern.

Car Coupling in England.—In England, as well as here, railroad men are struggling with the car-coupling problem. There, as in this country, attention was called to the subject by the many accidents to employés in coupling cars, but the railroad companies do not seem to have taken it up with as much earnestness as they have on this side of the water. Very little has been done by the roads or their officers, and the most important work so far has been done by the employés themselves. The Amalgamated Society of Railway Servants, an organization to which we have nothing to correspond in

this country, some time ago made from its funds an appropriation of £500 to be distributed as prizes for the best automatic couplers, and to cover the expenses of trials. These trials were made at Nine Elms, on the London & Southwestern road, last March, when a number of couplers were tried and prizes awarded. No practical results, however, have yet followed the trial, the average English mechanical superintendent being, apparently, much more reluctant to act on this question than his American brother.

Hennepin Canal.—The Secretary of War has transmitted to Congress a report of the Board of Engineers appointed to examine the line of the proposed Illinois & Michigan Canal, better known as the Hennepin Canal. The report is generally favorable, and the Secretary says that the construction of the canal will be a commercial benefit to the country; whether that benefit will be so great as to justify its construction, is left for Congress to decide.

The report says that the construction of the canal is feasible and discusses the routes proposed, which are three in number, the line to Rock Island, the Watertown line and the route by the Marais d'Osier, reaching the Mississippi at Albany, Ill. The board believes that while the Marais d'Osier route is preferable from an engineering point of view, as the shortest and cheapest and involving the least lockage, yet, in view of the relations of the Canal to existing transportation lines, it is inclined to recommend the southern, or Rock Island route.

These conclusions of the board are approved by Gen. Duane, Chief of Engineers.

New Bridge at St. Louis.—A bill has passed both Houses of Congress, providing that the St. Louis Merchants' Bridge Company, of St. Louis, may build a bridge across the Mississippi at some suitable point between the present bridge and the mouth of the Missouri. It is also provided that no bridge shall be constructed across the Mississippi River within two miles above or two miles below the bridge heretofore constructed, known as Ead's bridge. Said bridge shall be constructed to provide for the passage of railroadtrains, and, at the option of the persons by whom it may be built, may be used for the passage of wagons and vehicles, for the transit of animals and for foot passengers; the bridge shall be made with unbroken and continuous spans, and it shall have at least two channel spans of not less than 500 feet clear width each, and one span of 300 feet clear width of channel way; provided, said bridge may have not less than two spans of not less than 750 feet each, clear width of channel way, if thought best, instead of three spans as aforesaid. The channel ways are to be measured at right angles to the current at any and all stages of water; and said span or spans shall not be of less elevation in any case than 50 feet above high-water mark, as understood at the point of location, to the bottom chords of the bridge, and the piers of the said bridge shall be parallel with the current of the river.

The projectors intend to build the bridge north of the present bridge, and to establish, in connection with it, a new union station for such railroads as may use the bridge.

New Jersey Junction Railroad.—This new road, which is now nearly completed, is a work of some importance, forming a sort of belt line around Jersey City and Hoboken, and connecting the lines running to the Hudson River. It begins at Weehawken Ferry at the east end of the West Shore tunnel, passes straight along the shore, around King's Bluff, and through the stock-yard, coal and oil docks of the Erie road. Thence it runs at the foot of the hill on the western edge of Hoboken, and passes under the Delaware, Lackawanna & Western, a little east of the east end of the tunnel under Bergen Hill. It then rises along the bluff, crosses the Erie road on an iron viaduct 300 feet in length. This is about 200 ft. east of the east end of the Erie Co. tunnel under Bergen Hill. The road then descends, and passes under the Harsimus freight line of the Pennsylvania road to a connection with the new main passenger line of the Pennsylvania road, now in course of construction. A branch road connects with the freight line near Sixth and Division streets, Jersey City. To the connection with the Pennsylvania Passenger line the road is 4½ miles long. The Harsimus branch connection is ¼ mile long. From Weehawken to connection with the Erie it is constructed with three tracks, two of which are used as the main track, and the third one for the Erie road's connection with its oil, stock and coal business of their Weehawken terminal. The road is now completed to the viaduct over the Erie. The work of construction is being done by the New York Central & Hudson River Company. From the Pennsylvania tracks to Communipaw it is continued by the National Docks branch of the Pennsylvania Railroad.

Meigs Elevated Railroad.—Mr. George Stark, Civil Engineer, has made a report to the Massachusetts Railroad Commissioners, on the experimental section of elevated railroad, on the Meigs pattern, which has been built in East Cambridge., This section has a grade of 120 feet and one curve of 50 feet radius. It is equipped with an engine weighing 30 tons and a passenger-car weighing 17 tons. Mr. Stark's report gives the following conclusions:

"The experimental section of the Meigs elevated railway now in use at East Cambridge is, in my opinion, abundantly strong for its intended use as an elevated railway track, and is safe for the passage of its equipment.

"The rolling stock and motive power used thereon is also strong and safe for its intended use, no breakage having occurred, or being likely to occur, that could imperil personal safety, either in or out of the cars.

"A line of railway, properly constructed on this principle, for passenger or freight traffic, and equipped with such rolling stock and motive power, on this principle, as the Meigs company is now prepared to perfect and build, would, in my opinion be, at least, as strong and safe for any kind of traffic as the ordinary surface or elevated steam railways now in common use.

"In view, however, of the imperative necessity for the best class of design and construction in everything appertaining to an elevated railway, I think it would be wise for the State of Massachusetts, through its Board of Railroad Commissioners, or otherwise, to regulate the strength and design of all materials used in construction, and the weight and design of equipment to be run, etc."

Logging Railroads in the United States.—The *Northwestern Lumberman* has been collecting statistics as to railroads used exclusively for logging or lumbering purposes, and gives the following statements:

Number of Railroads	383
Total length, miles	2,288
Number of locomotives in use	428
Number of cars in use	5,182

The total mileage includes 1,011 miles of standard gauge and 1,001 miles of narrow gauge. Of these roads 291, with 1,851 miles of track, are laid with iron or steel rails and use locomotives; 92 roads, with 399 miles of wooden and 38 miles of iron track, use animals as motive power. Most of the wooden roads are temporary affairs only. The more permanent lines with iron rails represent a considerable investment for construction and equipment.

The average length of these logging roads is about 6 miles only, but there are some of considerable length, one in Arkansas claiming 45 miles; one in Virginia 45; one in North Carolina 30, and one in Michigan 36 miles.

The variety of gauges is great, the narrow-gauge lines including roads of 24, 30, 36, 39, 42 and 45 in. The *Lumberman* counts up 37 different gauges in all. Not all are narrower than standard gauge, however, Washington Territory reporting roads of 7 ft. 6 in., 8 ft., 8 ft. 4 in. and 9 ft. gauge. These very wide gauge lines are all short, and all, except one, have wooden rails, and are operated by ox or mule power.

Michigan, as might be expected, leads the list, having 54 roads, with 283 miles of track, 60 locomotives, and 1,370 cars. Georgia is second, having 32 roads with 225 miles of track, 61 locomotives, and 244 cars. Other States having a considerable mileage, are: Florida, 176; South Carolina, 170; Pennsylvania, 168; Texas, 153; Alabama, 146; Virginia, 126, and California, 114 miles.

It must be remembered that many of these logging roads are not permanent in their nature. They are used until the adjoining section is stripped of its lumber, then taken up and laid elsewhere. Some, however, gradually develop into permanent lines, and are used for general business after their original purpose has been served. This has been the case with several lines in North Carolina and Georgia, where local railroads have grown out of logging tramways.

Ordnance for the Navy.—Commodore Montgomery Sicard, Chief of the Bureau of Ordnance, in his annual report to the Secretary of the Navy, says that during the year a number of the 6 in. high-power steel guns have been finished and fired at the naval ordnance proving ground. They have all endured proof in a very satisfactory manner, and over 2,000 ft. muzzle velocity was readily obtained with standard powder and projectiles and moderate chamber pressures. The two 5-in. guns for the *Chicago* have been finished since the last report. One has been fired with very satisfactory results. The first 8-in. gun finished, has also been proved with the same results. Chase and muzzle hoops for heavy guns have been made in the United States, and, as far as fitted, are satisfactory in quality. The 2-in. guns are well advanced. Under the head of projectiles Commodore Sicard comments upon the unsuitable character

of cast-iron as a material for projectiles intended to be used in high-power guns, and the failure of steel-makers to supply unhammered cast-steel shells of good quality. The report also states that unsatisfactory results have attended the efforts of the Bureau to use unhammered cast-steel for gun-carriages, but samples have recently been submitted and severely tested with results that encourage persistence in the effort. Under the head of machine guns and cannon the report notes the tendency abroad to increase the caliber of such cannon, and the opinion is expressed that pieces throwing projectiles of 20 and 30 pounds will soon be perfected. Cartridges for Hotchkiss guns have been produced in this country which perform better than those made abroad.

Touching the armament of the new vessels, Commodore Sicard says: "For the new ships approaching completion we have eighteen 6-in. and two 5-in. guns finished, and three 6-in. and five 8-in. well advanced, together with all the carriages for the *Atlanta* and *Boston* and all for the *Chicago* except the 8-in. All the guns of the secondary batteries and nearly all the small arms have been provided, and all the electric search lights and appendages. The mounts for the secondary batteries are being pressed; most of the powder of the *Atlanta* and *Boston* is delivered, and that for the *Chicago* will be ordered speedily. The equipments of the unfinished ships are now in a forward state. The South Boston Iron Works have virtually completed the 6-in. guns, which are to be assembled and finished there, and the two 8-in. guns are being pushed. The West Point Foundry has made good progress on the guns that are to be finished there. The contract of the Midvale Steel Works for 6-in. forgings is nearly filled, only a few remaining to be furnished."

As the third-rate wooden ships last built are good examples of the best class of wooden vessels, and must be depended upon to do most of the work of the navy until replaced by new ships, the report says it is desirable that they should receive a modern armament, as the impression they produce without it is but slight. When they are replaced, the armament will answer for the newer vessels. A new site for the naval ordnance proving ground is recommended in view of the unsuitable character of the ground now in use. A class of 21 commissioned officers and four gunners received instruction during the summer months on torpedo warfare. The estimates submitted for the next year aggregated $8,741,494, including $1,500,000 toward the armament of vessels authorized, and $1,086,750 for fuel, labor, general armament, and a new proving ground.

Arthur Kill Bridge.—The report of the Board of Engineers to the Secretary of War on the proposed bridge over the Arthur Kill on the Baltimore & Ohio line to Staten Island, is accompanied by documents, giving in detail the data on which the report is based. It says that the amount of freight which annually passes the site of the proposed bridge across the Arthur Kill will approach 5,750,000 or 6,000,000 tons of actual freight, an amount in excess of the tonnage of foreign commerce cleared from New York for 1885. It is thus seen, says the report, that so far as tonnage is concerned, this is one of the great waterways of this country, and indeed of the world. Of this vast amount of freight probably nine-tenths is in tows, sometimes reaching 70 vessels to one tow. The tows are usually made up of five vessels abreast and are eight vessels long, and their dimensions are 100 to 125 ft. in width by about 800 ft. long. Under the plan submitted by the Staten Island Rapid Transit Company such masses of vessels are to pass through a clear opening between piers of about 200 ft. The report says that the experience at the draw at the mouth of the Raritan River, through which only about one-third as much freight passes as through the Arthur Kill, and which has 207 ft. draw openings, shows that the draw at that place is a serious obstruction to navigation and has caused considerable losses from delays and collisions. The tows to go north through the Arthur Kill pass the proposed site of the bridge while the tide is running flood, and when any collision would produce great damage. They are much larger than those passing through the Raritan draw, and it is impracticable for these large tows to anchor as the smaller ones do at the Raritan draw. The board is therefore of opinion that if a bridge were constructed as proposed, with a pier in the middle of the Kill, it would make necessary a large reduction in the size of the tows and the consequent increase in the cost of transportation, and it is of opinion that if there were a natural obstruction so serious as a pier in the middle of the stream its removal would be urgently and rightfully demanded, even at great cost. The obstruction is not there now, and should not be placed there to the injury of navigation in order to save a few hundred thousand dollars to the railroad company.

The proposed bridge, the report says, is also of insufficient height, the lowest part of the superstructure being only 34 ft. 8 in. above mean low water. For these reasons the board recommends to the Secretary of War a bridge at the site proposed, the channel face of whose east pier shall be on the Staten Island bulkhead or shore line, and whose channel span shall give a clear opening of 450 ft.; whose span next west shall be a draw span, giving 125 ft. clear opening, the lowest parts of these spans being 50 ft. above mean high water. The foundations of the pier should be so arranged as to admit future deepening of the Kill to 20 ft. "Such a bridge will be an obstruction and an inconvenience," the report says, "but will not in any serious degree increase the cost of transportation. It involves some increase of cost to the railroad company, but no more than it should bear rather than infringe on the pre-existing rights of navigation."

A draw on the proposed Buckwheat Island site, the report says, would be impracticable for the reason that the channel has only 6 ft. of water on one side and on the other side the channel is narrower than at the site recommended.

No action has yet been taken on this report by the Secretary. A bill has been introduced in Congress to amend the act passed last year in accordance with the engineers' suggestions.

Park Electric Brake.—This brake, which is to take part in the Burlington trials next April, was recently tried on the Chicago, Burlington & Quincy road. It is thus described:

"A dynamo is placed on the locomotive, and is driven by a small independent engine. The whole affair is easily detached from the locomotive and weighs about 400 lbs. Three wires run the length of the train, and at each end of each car are coupled together by a very simple device, one coupling serving for the three wires. The brake is non-automatic, or in other words, does not apply in case of a break-away, but it is proposed to add a storage reservoir at the rear end of the train, whereby the conductor could apply the brake in case of the train parting. As, however, applied to the trial train, the brake is non-automatic, and the current only runs through the wires when the brakes are being applied or released from the engine. Normally, when the train is running, or standing with the brakes off, there is no current in the wires.

"The engineer applies and releases the brakes by moving a lever on an electric switch-board on the engine. The current applying the brakes runs to the end of the train through one wire and returns through the center wire of the three used. When the lever on the switch-board is moved to the release position the current runs through the third wire, releasing the brakes, and returns through the center wire as before. Whenever the coupling at the end of the train is pulled apart, the wires automatically make the proper connection in the coupling, so that the current when applied will make a circuit the length of the train and through the center wire. It will thus be seen that the couplings require little attention. They are very easily coupled by a single operation, and the coupling at the end of the train is simply allowed to hang loose, and does not require to be placed in a rest or closed with a plug or a stop-cock or any similar contrivance.

"To apply the brake shoes, an eccentric is mounted on one axle of each car. The end of the eccentric rod can, by means of pawls, be made to engage in ratchet teeth on the periphery of a cast-iron drum, carried on the under-side of the middle sills of the car. This drum also carries a chain which is attached to the brake and levers in the usual manner. The passage of an electric current along the train causes the pawls worked by the eccentric current rod to engage the drum, which consequently rotates and winds up the chain applying the brake shoes. A second pawl prevents the drum running back when the pawl driven by the eccentric rod is moving back to take a fresh stroke. When the current applying the brake is stopped (by the lever or the switch-board being thrown into the middle or neutral position), the applying pawl ceases to act, but the second pawl retains the brake on. When the releasing current is passed through the other wire, this second pawl is thrown out of gear, and the brakes come off. It is probable that these details will be somewhat modified.

"As the brake is applied by a few revolutions of the wheel, the shoes are full on in a very short space of time, and must be applied simultaneously throughout the length of a train, however long. The brake can be adjusted so as not to slide the wheels. When the brake is applied with what is deemed sufficient force, a small set-screw forms a contact, and shunts the current that holds the pawl applying the brakes. This pawl then drops, and the brake-chain drum is no longer revolved. The brake therefore continues to be applied with the proper maximum amount of force and is not released, the drum being prevented from running back by the second or retaining pawl already described. This pawl can only be lifted by the releasing current or by hand."

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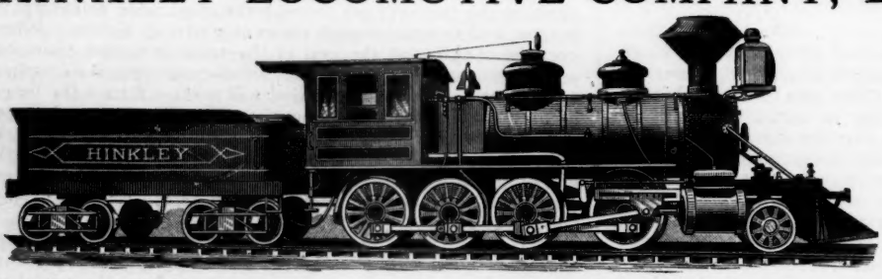

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